THE COMPLETE GUIDE TO MILITARY MAP READING

NUMEROUS EXERCISES
& FULLY ILLUSTRATED

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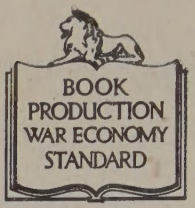
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TENTH EDITION

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PREFACE

In the following pages an attempt is made to deal with the subject of Map Reading in a really *practical* way.

The Author has kept in view throughout the Syllabus for Map Reading Examinations for First and Second Class Certificates of Education.

It should be noted that although the answers given to the exercises in this book are necessarily brief, and only just sufficient to help students, in examination work candidates must show clearly how their results have been obtained, and must give reasons for arriving at any particular conclusion.

The Publishers supply loose copies of the following :—Plate D at 1s. 6d. per dozen (per post, 1s. 8d.) ; and Plates F, K and L at 9d. per dozen assorted (per post 10d.). These will be found useful for students working out exercises.

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INTRODUCTION

In order to be able to read a Map it is necessary to know—

(*a*) The meaning of the conventional signs and terms used.
(*b*) The scale of the map and how to use it.
(*c*) The direction of True North.
(*d*) The magnetic variation for the particular map and the yearly increase or decrease of that variation.
(*e*) The method of showing differences of level and hill features.

To this should be added for military maps—

(*f*) The meaning of the symbols used in Field Sketching.

The scale of a map is invariably indicated in some way, and as a rule a complete map has an explanation table showing the meaning of the conventional signs, etc., but not always.

The direction of the True North is generally indicated by a North Point; if not, the sides of the map can, as a rule, be taken as true N. and S.

On the new issues of gridded maps the side sheet lines are *grid* north and south.

For all practical purposes in the British Isles, Grid North and True North are taken as being identical.

The method of showing hill features must be clearly understood. In maps used for military purposes the usual method is the contour system. This system must be thoroughly studied, and students should frequently practise problems on the visibility of points, gradients, etc.

THE COMPLETE GUIDE TO MILITARY MAP READING

CHAPTER I

MAPS AND MAP READING

ORDNANCE maps are issued in a variety of scales, according to the purposes for which they are required.

The maps at 6 ins. to a mile show much detail and are used by engineers, local authorities, etc.

The 1 in. map is best suited to Service conditions generally, and is largely used in infantry training. It is an excellent road map and shows contours at a vertical interval of 50 ft.

At present, $\frac{1}{25000}$ maps (2·53 ins. to a mile) are issued for artillery, but these maps are not usually available for general purposes.

The higher formations of an army, from Divisions upwards, would probably use a map at a scale of $\frac{1}{4}$ in. to a mile.

All these maps are the work of highly skilled surveyors, but there is another class of map, the military sketch, which has been prepared on the ground by regimental personnel and more often is made by enlarging a portion of an ordnance map. This sketch is intended to fulfil some particular purpose, such as showing billeting areas or company positions.

On opening a map for the first time the scale should always be looked for ; the V.I. of the contours and the variation of the compass should be noted ; and the list of conventional signs at the foot of the map should be consulted.

It is essential that all who use a map should be able to recognize its main features. The most important points in a line of march should be noted beforehand. It is an interesting exercise to attempt to visualize the view, or the field of fire, from a particular point on the map, and then to compare the result with the actual view on the ground. The results may not be encouraging at first, but practice will greatly improve ability in this respect.

The actual comparison of the map with the ground is of the greatest importance and should be practised at every opportunity.

Those students who may not have at hand a Service map of the gridded type, can do much useful practical map reading on the ground with the Ordnance Survey 1 in. Map, Popular Edition, of the locality, which may be purchased from a bookseller for 1s. 6d.

CHAPTER II

CONVENTIONAL SIGNS

CONVENTIONAL signs are used on maps to represent objects and natural features in order that the greatest amount of information possible should be given, while at the same time the detail is kept clear and intelligible.

These signs fall into two classes :—

(*a*) *Ordnance Survey signs* which are used on the official maps. Every map has an explanatory plate of conventional signs, and these should be studied carefully until each sign can be readily recognized. When out at practical work it is necessary to compare objects on the *ground* with their representation on the map.

In cases where the object depicted is comparatively small, the size of the conventional sign has to be exaggerated on maps of a scale of 1 in. to 1 mile, or smaller, so that the detail will show up clearly. This is often the case with such objects as buildings, churches and roads.

In such cases the exact position of the object on the map is the centre of the sign when it represents the plan of the object, and the centre of the base when the sign represents the side view or elevation. Fig. 1 illustrates this, the exact position being indicated by the arrow.

FIG. 1.



(*b*) *Signs used in field sketching*—these are given on Plates B and C. They are simple and are readily understood, and as they occupy little space, the position of the object can be shown with accuracy. They are to be used in all field sketches, enlargements, etc., and the student should practise drawing these signs as small and neatly as possible consistent with clearness. Candidates for the Army 1st Class Certificate must use these signs in their work.

The following notes on certain of them should be read when those particular signs are being studied :—

Roads should be drawn with continuous lines if they are fenced, or have any obstruction, such as a ditch or bank, which would interfere with troops moving freely on or off them. If no such obstruction exists they should be drawn with pecked lines. At the margins of a map or sketch roads should bear a note giving the distance to the next town or village, thus : TO ASH, 3 miles.

The following comprehensive method of classification has been adopted for roads on military maps and sketches :—

(1) *Letters* to indicate width.

A—Roads wide enough to take two streams of traffic.

B—Wide enough to take one line of traffic only, but occasional vehicles can pass the line.

C—Wide enough to take one stream of traffic only ; vehicles can pass only at definite passing places.

(2) *Figures* to indicate the nature of the road.

No. 1 roads, capable of taking heavy guns and 3-ton lorries.

No. 2 roads, capable of taking M.T. up to 30-cwt. lorries.

No. 3 roads for Horse Transport only.

No. 4 roads which can take pack transport only—may be merely bridle paths.

The grouping of these factors is shown in the table which appears on page 78 of the official Manual of Map Reading.

A sketch should have the appropriate description, such as A2, marked plainly alongside the road on the sketch. If, as sometimes happens abroad, a road deteriorates in the wet season to say A3, then the second state should be shown in brackets after the first classification, thus : A2 (A3).

Any information as to the material with which a road is metalled will be of value in indicating its wearing qualities.

It should be noted that gravel is a road metal.

A **railway** is shown by a continuous black line with cross-bars. The word *single* or *double* should be written alongside, and a note should be made of the gauge. Most railways of the United Kingdom are *standard gauge*, but there are some *narrow* mineral lines and others with *tramway* tracks. In India the tracks which are wider than the standard are called *broad gauge*.

Telegraph or **telephone** lines, when used as air lines or a cable, are shown by continuous black lines marked with dots at regular intervals. (Care should be taken so that these dots are not made in such a way that they can be confused with the cross-bars of the railway conventional sign.) If the line be buried, it should be represented by a series of short disconnected lines each of which bears a dot.

Rivers over 15 ft. wide are generally shown by double lines ; but in all cases the width and depth at particular points will be given *in feet*, together with the height of the banks, thus : 60 w, 16 d, —7.

(*Note.*—In giving the height of the bank the minus sign denotes the level of the river surface below that point on the bank.)

Bridges.—The construction of bridges should be denoted by the use of words such as *iron*, *stone*, *wood*, *boats*, etc. The weight capacity in *tons* should be given thus (5). In the case of a ferry it is useful to denote whether it is capable of transporting vehicles (V) or foot-passengers only (F).

When drawing an **embankment** or a **cutting** care must be taken to make the hachures at right angles to the road, etc. In the case of an embankment the hachures are drawn outwards from the road, and in the case of a cutting, they are drawn towards the road, from the line which marks the top of the cutting. If possible, the height of an embankment *in feet* should be noted thus : +9, or the depth *in feet* of a cutting thus : —18.

In the case of **woods** it should be noted what the timber is—*e.g.*, pine, oak, orchard, or mixed, etc. ; also the average spacing of the trees in feet and their average diameter in inches, thus 18s. 10d. means that the trees are about 18 feet apart and their average diameter is 10 inches.

In the case of **scrub** it should be stated whether it is dense or open.

Villages which have Post Offices with telegraph are marked T, while those which have merely a Post Office are marked P ; but a non-telegraph office which has a telephone is often marked P.t.

When **troops** are shown on a sketch, the symbols will not be drawn to scale. The unit and strength will be shown alongside.

Of the **north point** signs, magnetic north is marked with an arrowhead and the word *magnetic* written along the line ; the true north, or grid north, line is marked by a star or cross-bar.

NOTES ON THE 1 IN. MAP AT PLATE A

Roads.—The main roads are marked in a yellowish-brown colour. Those with more than 18 feet width are shown wider than the others. These are first-class main roads suitable for fast traffic.

Those marked by a continuous brown line are fit for ordinary traffic, while those with a broken brown line are classed as indifferent or winding. Roads shown with no colouring are definitely bad.

Where a road is at a gradient steeper than 1 in 7, the fact is recorded by a broad arrow-head.

Where the gradient is steeper than 1 in 5 two arrows are drawn.



Heights.—The contours show 50 ft. intervals. Note that the 250 ft. contour is thickened ; this is the case also with the 500 ft., 750 ft. and so on, contours.

Along the roads spot levels give the height in feet. These usually are given where there is a change of slope, not necessarily at the top or bottom of a hill. Note that the figures for these are of a different type from those which denote milestones, or mile distances.

Other spot levels are marked away from roads by means of triangles with the point in the middle; these are generally spoken of as trig. points, for they are used in the trigonometrical survey. From these points there is a good field of view in at least one direction.

Railways.—Note the difference in marking between a single line and a double line railway. The one through Bramley station is a single line. All the others are double line railways. Note the marking of the stations; the large station in Guildford has a rectangular marking, not a circle.

CHAPTER III

IDENTIFICATION OF POINTS ON MAPS

Some simple method, or system, for describing the position of a point, or place, on a map is essential for quick and accurate identification.

On small-scale maps or atlases a place is, as a rule sufficiently accurately described if its latitude and longitude are known.

This is the normal system of geographical co-ordinates. In other words, the map is "graticuled."

When dealing with maps of a scale of $\frac{1}{250000}$ or larger, this method of identification becomes inconvenient and slow. For military purposes, when speed and accuracy are essential, some simpler system is necessary.

The maps we have under consideration are the Ordnance Survey maps, of scales 1 in. and $\frac{1}{4}$ in. to the mile, and the $\frac{1}{25000}$, which, in this country, are the ones in general use for military purposes, although elsewhere the student may meet maps on a scale of $\frac{1}{250000}$ (small scale), $\frac{1}{50000}$ (medium scale), or $\frac{1}{25000}$ (large scale).

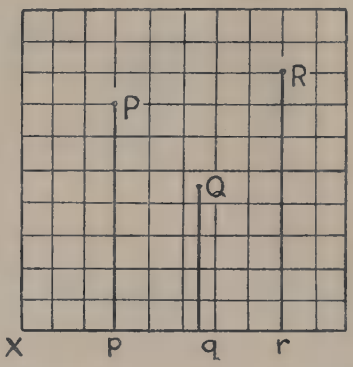
Before examining the various systems in existence, the reader should thoroughly understand the system of co-ordinates. The following remarks explain the general principles.

Consider Fig. 2, which represents simply a square with points *P Q* and *R* lying inside it.

Whatever the length of the side of the square, each is regarded as being divided into ten parts, with parallel lines drawn across the square as shown in

Fig. 2. Similarly the side of each small square is regarded as being sub-divided into ten parts. The position of a point within the square is determined with regard to the left-hand bottom corner, which is here called *X*.

FIG. 2.



The position of *P* relative to *X* is expressed by the lengths *Xp*, *pP*. These are termed the co-ordinates of *P*. *Xp* is called the *easting* and *pP* the *northing*. The simplest method of counting gives 3 to the east, and 7 to the north, so that the point is fixed by the reference 37; but the more usual way is to take into account the sub-division of the smaller sides into tens, and so the count to the east is 30, while the northing is 70, and the reference is 3070. In practice, it is usual to denote the small square of which *P* is at the left-hand bottom corner, by the figures 37.

Similarly the position of *R* is given by 8080 and its small square by 88.

To find the position of *Q*—the easting gives 50 for the whole squares and 5 of the ten forming the side of the small squares, a total easting of 55; the northing is similarly 45, and the reference is 5545. The point *Q* is situated in square 54.

Note that the easting is always given first and the result must contain an *even* number of figures. So in the first vertical column where the easting must be less than 10, the easting figure will be preceded by a nought, thus 06. Similarly in the lowest horizontal line of squares the northing will be less than ten, and the northing figure will be preceded by a nought.

The exercises given later will, it is hoped, make this clear, though it will be readily seen that the position of *X* is 0000.

GRIDDED MAPS

The British System

A brief description of this system will suffice, as it has been replaced by the Modified British System and will seldom be encountered.

The whole area of the British Isles is considered as being covered with a huge grid of ten-kilometre squares, each square being designated by a letter. These 10-km. squares are sub-divided into a hundred smaller squares, each of whose sides is 1 km. long. The lines bounding the 10-km. squares are thickened for clearness. The position of a point is described by giving the letter of the square in which it lies and its co-ordinates within that square.

The system has to be repeated every 50 km. since there are only 25 letters in the alphabet (excluding I), and this is liable to lead to confusion on small-scale maps, as there will be two or more places on the same map with identical map references.

The Modified British System

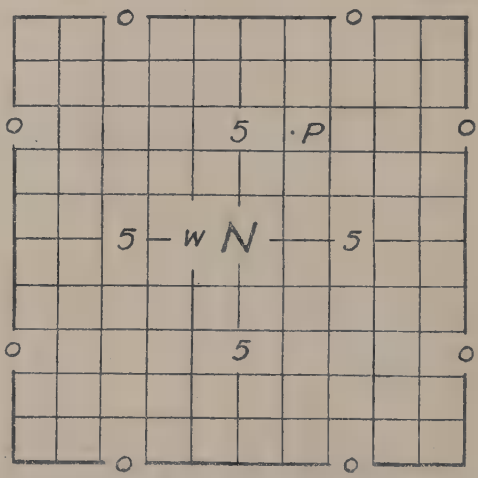
This system overcomes the difficulty of references being duplicated. The whole area is first divided into squares the length of whose sides is 500 km. and these squares are sub-divided into 25 squares of 100 km.

side. The large squares are designated by letters and the 100-km. squares are also lettered from *A* to *Z*, omitting the letter *I*. These smaller lettered squares are again sub-divided into 100 squares of 10 km. side, and, on the medium and large-scale maps, the 10-km. squares are further sub-divided into squares of 1 km. side.

Thus, over the whole area it is possible to describe a place without fear of duplication and the reference of that place is the same whatever the scale of the map.

(*a*) On small-scale maps (10 miles to the inch) the letter describing the 500 km. square is given first, then the letter of the 100 km. square in larger type, followed by the co-ordinates of the point within that 100 km. square. Thus in Fig. 3 the map reference of point *P* is w*N* 6375.

FIG. 3.

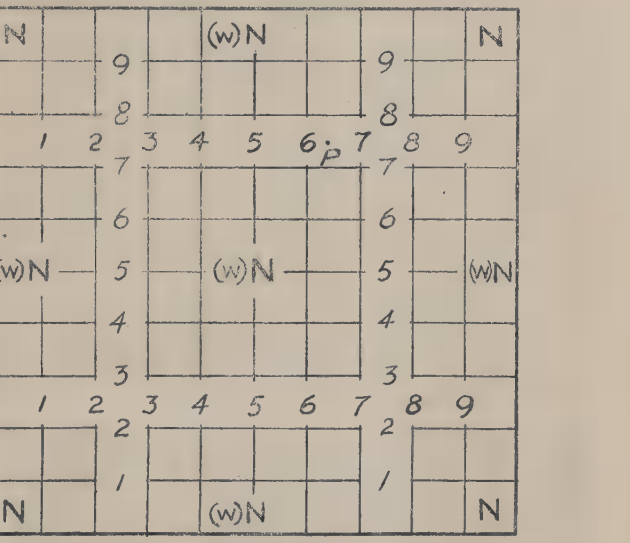


The letter *N* describes the 100 km. square as drawn, and the letter w describes the 500 km. square in which square *N* lies.

(*b*) On maps of $\frac{1}{4}$ in. to 1 mile, or $\frac{1}{250000}$, as well as on the 10 miles to 1 in. scales, the sides of the 100-km. squares are drawn in thick lines and the sides of the 10-km. squares are drawn in thin lines.

Fig. 4 illustrates the method of numbering the squares on the $\frac{1}{4}$ in. and $\frac{1}{250000}$ maps. The reference of point *P* is again (w) *N*6375, but it is not necessary to insert the (w) unless the reference may have to be transferred to a 10 miles to 1 in. map.

FIG. 4.



It will be realized that it is possible to print more numbers on this map as the scale is larger, so that map references may be picked out more readily.

(*c*) On maps of a scale of 1 in. to 1 mile or larger, the area covered is small; therefore there is no danger of duplication and the letters describing the 500 km.

and 100 km. squares are omitted. In case, however, references may have to be transferred to a smaller-scale map, a diagram is always given in the margin showing the position of the particular sheet in relation to the lettered squares, so that a full grid reference can be given if required. Instructions are also given for finding a grid reference, although these are usually omitted from maps printed for written examinations.

Plate D (facing p. 18) illustrates the method of numbering the squares on the 1 in. to 1 mile map. It will be noted that every tenth grid line is thickened; in other words, the sides of the 10-km. squares are thickened. The grid lines are all numbered round the margin of the map. The small number before every tenth number is added so that the full co-ordinates of a point can be given if necessary. These are sometimes known as survey co-ordinates. The origin of the system has been assumed as a point in the sea south-west of Cornwall, and the co-ordinates are measured east or north of this point. Thus on Plate D the figure $^{4}50$ indicates that that line is 450 km. east of the origin, and the figure $^{1}10$ means 110 km. north of the origin. The full co-ordinates of the cross-roads at Hood are therefore 454,700 metres east, and 103,800 metres north of the origin.

Fig. 5 illustrates a small portion of a $\frac{1}{25000}$ sheet. The grid lines are numbered in the same way as on the 1 inch map and the squares are still 1 km. long. They appear much larger as, of course, the scale is more than twice as large.

On the 1 in. maps and those of smaller scales the grid lines are in mauve because they are superimposed on maps already printed for other purposes. The $\frac{1}{25000}$ map is specially prepared for military purposes and the grid system is incorporated in the original printing.

How to Give a Grid Reference.

(*a*) *Four-figure references.*—A grid reference describes the bottom left-hand corner of a square with reference to a point of origin. The full survey co-ordinates refer to the point of origin of the grid system as already described. The ordinary grid references refer to the bottom left-hand corner of the 100 km. lettered square in which the point lies.

In Plate D the reference 5101 indicates the south-west corner of the square in which the Mill is situated. This corner is 51 km. east and 10 km. north of the origin of the 100 km. square. The four-figure reference refers to the whole of that square, the length of whose side is 1 km. or 1,000 metres.

The grid reference of the square in which Barham Park lies is 5305.

(*b*) *Six-Figure References.*— If the position of the Mill has to be described more accurately, the sub-division of the square into 100 smaller squares of side 100 metres must be estimated and a six-figure reference given. In this case it would be 515010, which would be the description of a square of 100 metres side and would refer to anything in that square. Thus a six-figure reference brings one to within 100 metres of a point.

(*c*) *Eight-Figure, or Pin-Point, References.*—If even greater accuracy is required, as for instance when plotting ranges on a $\frac{1}{2500}$ map, an eight-figure reference must be given. For these, the 100 metre squares are further sub-divided into 10 metre squares and the reference describes the south-west corner of a 10 metre square. This will bring one to within 10 metres of a point, and is sometimes called a Pin-Point reference.

The "Romer."—Obviously, some method of measuring the sub-divisions of the grid squares is necessary for finding eight-figure references, and for this purpose

a Romer should be used. If the student does not possess one on his Service protractor, it is easy to make one with a small sheet of stiff paper, or thin cardboard.

FIG. 6.

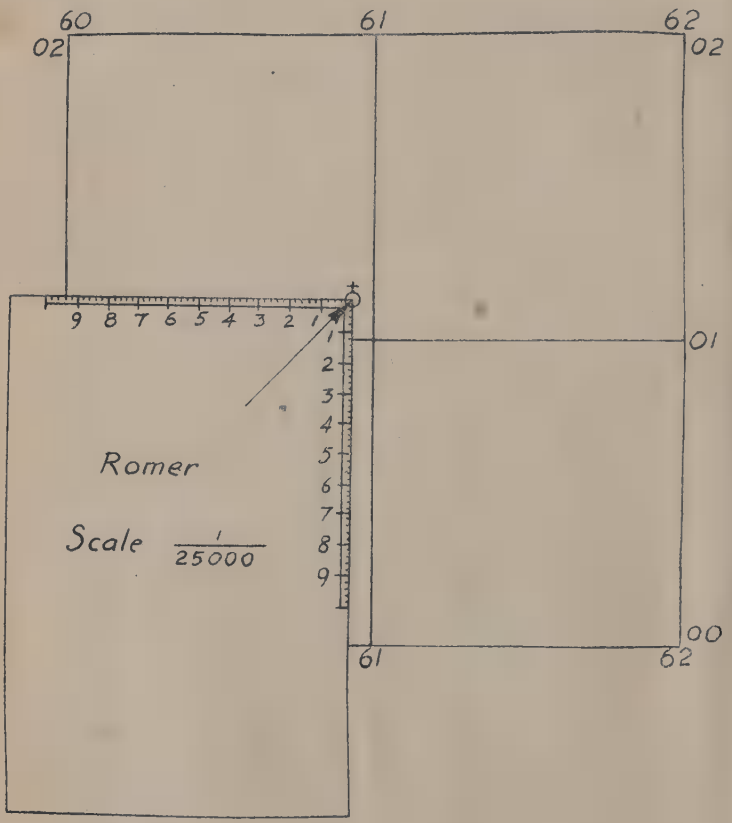


Fig. 6 illustrates a Romer for a $\frac{1}{25000}$ map and how it should be used. The divisions on the Romer should be marked off from the scale of metres at the bottom of the map. In this case it will be seen that the pin-point reference of the church at Ryton (Fig. 5) is 60940112.

The church is 940 metres east of the 60 grid line, and 120 metres north of the 01 grid line.

As few figures as possible should be used when giving a grid reference, provided that the point is clearly described without fear of ambiguity. A village can usually be described by the four-figure reference of the kilometre square in which it lies. Similarly a four-figure reference may be adequate for a church, or a cross-roads, as long as there is no other church or cross-roads in the same square. If there is any doubt about it, then a six-figure reference is better. Thus, "Cross-roads in Square 6201" (Fig. 5) can only refer to the cross-roads at The Priory.

Grid References Generally.—In reports and orders, when describing well-defined places, such as villages or woods, a map reference must always be given the first time they are mentioned. Thereafter, the references may be omitted.

The fact that the thin grid lines are 1000 metres (or approximately 1,100 yards) apart, is a valuable aid in estimating distances on a map.

The north and south grid lines all indicate the direction of grid north and may be used when plotting grid bearings.

When describing an area by means of map references, the description should start at the top corner and work round the area in a clockwise direction, giving the map references of the corners.

EXERCISE I

A.—Exercises on Plate D.

("One inch" Grid.)

1. In what squares are the following :—

(*a*) Barham Church.
(*b*) Nelson House.
(*c*) Hood School.
(*d*) Notown Station.
(*e*) Deep Halt.
(*f*) Brown's Farm.

2. Give the map references of the places given in Question No. 1.

3. What points are indicated at :—

(*a*) 538001.
(*b*) 513012
(*c*) 575016.
(*d*) 540005.
(*e*) 504046.
(*f*) 545095.

4. Give map references for :—

(*a*) Cross-roads at Nelson.
(*b*) Road junction at Barham.
(*c*) Road junction near Hospital.
(*d*) Deep Church.
(*e*) Horden Church.
(*f*) Notown Church.

5. What points are indicated at :—

(*a*) 547038.
(*b*) 492054.
(*c*) 500004.
(*d*) 593097.
(*e*) 561990.
(*f*) 504000.

6. Give the full survey co-ordinates for the position of the places in Question No. 1.

7. Give pin-point references for the position of the places in Question No. 4.

B.—Exercises on Figure 5.

($\frac{1}{2500}$ Gridded Sheet, Fig. 5.)

8. Give the six-figure map references for :—

(*a*) The Grange.
(*b*) Holmdean.
(*c*) The Ford.
(*d*) Bridge House.
(*e*) Poole School.
(*f*) The Well.

9. What points are indicated at :—

(*a*) 609011.
(*b*) 611005.
(*c*) 626012.
(*d*) 612018.
(*e*) 609015.
(*f*) 607008.

10. What are the eight-figure map references for :—

(*a*) North corner of West Wood.
(*b*) Low Farm.
(*c*) Hill House.
(*d*) Cross-Roads near Poole Church.
(*e*) The Garage.
(*f*) The Priory.

11. Write down the eight-figure references for the places in Question No. 8.

12. Give the full co-ordinates for the places in question No. 10.

C.—On Plate A.

What conventional signs are shown at :—

13. (*a*) 437701. (*b*) 428713. (*c*) 428740.
14. (*a*) 429707. (*b*) 441688. (*c*) 457725.
15. (*a*) 428709. (*b*) 467700. (*c*) 438707.
16. (*a*) 406703. (*b*) 405681. (*c*) 408693.
17. (*a*) 414661. (*b*) 415656. (*c*) 484672.

CHAPTER IV

SCALES

THE various scales to which a map may be drawn have already been mentioned. Consider now, a map drawn at a scale of 4 ins. to a mile ; on it a length of 4 ins. represents a length of 63360 ins. (1 mile) on the ground. This proportion may be shown fractionally thus :—

$$\frac{\text{Distance on map}}{\text{Distance on ground}} = \frac{4}{63360} = \frac{1}{15840}$$

This fraction shows the actual relation that a distance between two points on the map bears to the distance between the same two points on the ground, and is called the *Representative Fraction* (the R.F.).

In addition there will always be the usual scale line divided into suitable units ; in this case, each division will show 500 yards. Look at Fig. 7 and note that these units are shown ; further, note the position of the *zero* which has on its left a primary division which has been sub-divided to show hundreds of yards. This method of marking the scale line enables a distance taken from the map to be read off easily on the scale.

So Fig. 7 demonstrates the three ways in which a scale must be shown on a military map sketch :—

(*a*) By a statement such as " 4 ins. to a mile."

(*b*) By the Representative Fraction (R.F.), $\frac{1}{15840}$

(*c*) By a divided scale line.

The idea of the Representative Fraction will probably be new to many who take up Map Reading for the first time, but it is very important, and the R.F. should

FIG. 7.

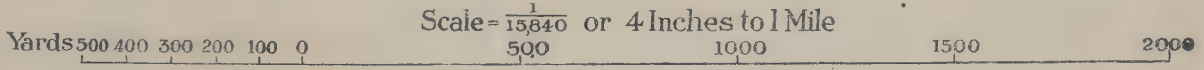


FIG. 8.

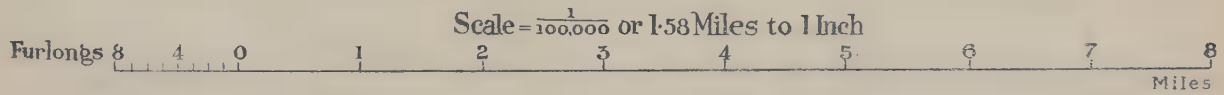
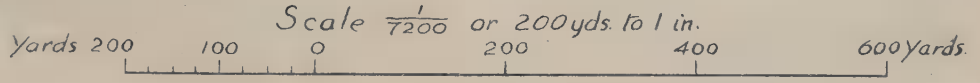


FIG. 9.



be noted when looking at any scale. The plan of a building may be at a scale of 1 in. to 2 ft. ($\frac{1}{24}$), or perhaps a barracks will be drawn at 1 in. to 100 ft. ($\frac{1}{1200}$); this form of stating a scale should always receive attention until the student becomes familiar with the idea.

Some maps are invariably mentioned by their R.Fs.; this is the case with the $\frac{1}{25000}$, $\frac{1}{100000}$, and $\frac{1}{250000}$ maps, where there is not an exact number of inches to the mile; the actual figure can easily be found as shown below :—

(i) $\frac{1}{25000}$. Here 1 in. on the map represents 25,000 ins. on the ground.

$$\therefore \text{No. of inches to the mile} = \frac{63360}{25000} = 2{\cdot}53 \text{ ins.}$$

$$\text{Also, No. of miles to 1 in.} = \frac{25000}{63360} = {\cdot}3945 \text{ miles.}$$

(ii) $\frac{1}{250000}$. No. of inches to the mile $= \frac{63360}{250000}$
$= {\cdot}25$ ins.

or, as is more usual in this case

$$\text{No. of miles to the inch} = \frac{250000}{63360} = 3{\cdot}94 \text{ miles.}$$

i.e., 1 in. $= 3{\cdot}94$ miles.

The following examples illustrate how R.Fs. may be found; notice that in each case the numerator must be 1.

(*a*) Scale : 4 ins. to a mile.

$$\text{R.F.} = \frac{4 \text{ ins.}}{63360 \text{ ins.}} = \frac{1}{15840}.$$

(*b*) Scale : 2 miles to 1 in.

$$\text{R.F.} = \frac{1}{2 \times 63360} = \frac{1}{126720}.$$

(*c*) Scale : 25·34 ins. to a mile.

$$\text{R.F.} = \frac{25{\cdot}34}{63360} = \frac{1}{2500}.$$

The R.F. is of special value when using a foreign map. The remainder of the scale may be given in unfamiliar units, but so long as the R.F. is known a scale may be constructed in British units.

THE SERVICE PROTRACTOR

The following scales are given on the Service Protractor which is illustrated on Plate E :—

(i) On the front—

$\frac{1}{50000}$. In metres and yards.

$\frac{1}{250000}$. In miles and yards.

$\frac{1}{25000}$. In metres and yards.

(ii) On the back—

1 in. to 1 mile. In metres and yards.

$\frac{1}{4}$ in. to 1 mile. In metres, miles and yards.

1/20,000. In yards.

Thus a scale is provided for practically any map the student is likely to come across. Moreover, other scales which may be needed can easily be constructed from one or other of these.

For instance, any scale which is a whole number of inches to 1 mile, such as 3 in. to 1 mile, can be made from the 1 in. to 1 mile scale.

Similarly, the $\frac{1}{4}$ in. to 1 mile can be used to construct one which contains a fraction of an inch to the mile, such as $\frac{1}{2}$ in., or $2\frac{1}{2}$ in. to 1 mile.

EXAMPLE 1.—To make a scale of yards showing 4 ins. to 1 mile.

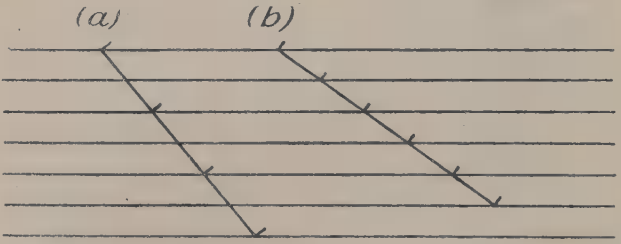
The scale line should be about 6 inches long. A study of the scale of yards at 1 in. to 1 mile will show that 10,000 yards occupy approximately 6 inches.

Draw a line 10,000 yards long measured on the 1 in. scale. At 4 ins. to the mile this distance will represent 2,500 yards. Divide this line into five equal parts, and again subdivide the left-hand division into five equal parts. The major, or primary, divisions will each represent 500 yards, and the smaller, or secondary divisions, will each represent 100 yards.

When completed, the scale should be numbered as shown in Fig. 7.

(*Note.*—Those who are not concerned with the theory of construction of scales may divide a line into any number of parts by utilizing the ruling which is common in notebooks and on squared paper; this last is very useful on account of the close ruling.)

FIG. 10.



(a) Line divided into three parts
(b) Line divided into five parts

To Make a Time Scale for Marching.

Example 2.—for a $\frac{1}{25000}$ map, construct a scale of distances covered by a battalion marching 3 miles an hour, showing intervals of 10 minutes.

The battalion will cover 880 yds. in 10 minutes, that is 1·27 ins. at a scale of $\frac{1}{25000}$. A suitable scale therefore would be 5·08 ins. long with primary divisions, 1·27 ins. each as illustrated in Fig. 11.

FIG. 11.

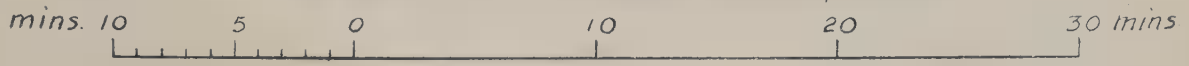


FIG. 12.

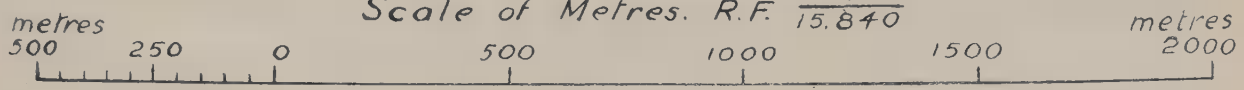
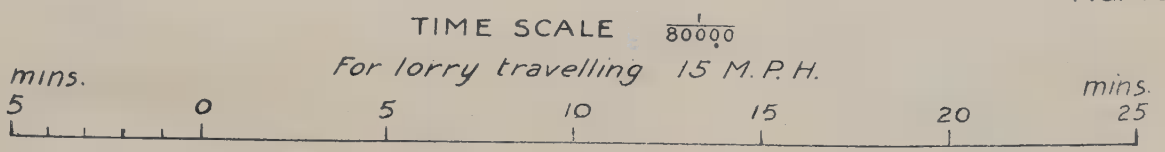


FIG. 13.



To Make a Time Scale for Motor Transport.

Example 3.—To construct for a $\frac{1}{80000}$ map a scale of distances covered by a motor lorry travelling 15 miles an hour, showing intervals of 5 minutes.

Now, in 5 minutes, the lorry travels $1\frac{1}{4}$ miles.

To get the length of a $1\frac{1}{4}$ mile division on the scale of $\frac{1}{80000}$, turn to the $\frac{1}{20000}$ scale on the protractor and take $\frac{5}{16}$ mile (550 yds.). These divisions represent 5-minute intervals, and six of them would form a convenient scale line.

Compare the result with Fig. 13.

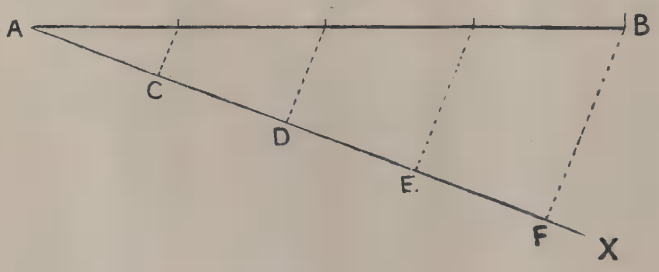
CONSTRUCTION OF A SCALE

It may happen that many map readers will never have need to construct a scale; yet a knowledge of the process cannot fail to be of interest. The following paragraphs may be omitted on a first reading of the subject.

Exercise.—To divide a line into a number of equal parts.

Method 1.—Applicable when the line to be divided is comparatively long and the divisions few in number. (Fig. 14.)

FIG. 14.



Suppose *AB* represents the line, 3·1 ins. in length, to be divided into four equal parts.

Set off an auxiliary line *AX* at an angle of 20°–40°; along this line mark off equal distances that are nearly the size of the required divisions ; in this case 0·7 in. would do. The divisions are shown at *C*, *D*, *E* and *F*. Now join *F* and *B*, and through the points *E*, *D* and *C* draw lines parallel to the line *FB*. The line *AB* will then be divided into four equal parts.

Method 2.—Applicable when the line to be divided is a short one, and the divisions comparatively numerous (Fig. 15).

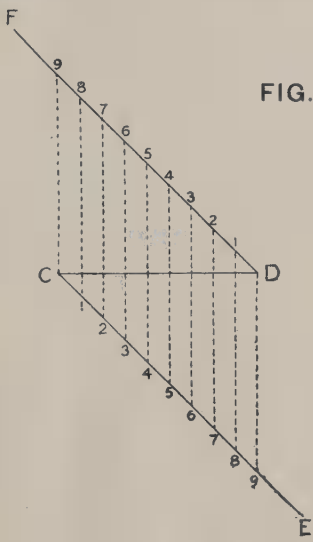


FIG. 15.

Suppose *CD* represents the line to be divided into nine equal parts.

From *C* draw the line *CE*, making an angle of 45°–70° with *CD*. From *D* draw *DF* parallel to *CE*, but on the opposite side of *CD*. Along *CE* and *DF* mark off

equal distances of suitable length of the required number of divisions (in this case nine), 1, 2, 3, 4, 5, 6, 7, 8, 9. Join *D*9, *C*9 ; 1, 8 ; 2, 7 ; 3, 6 ; 4, 5.

These lines (1, 8 ; 2, 7, etc.) cross the line *CD*, dividing it into the required number of equal parts.

It is best that the lines 1, 8 ; 2, 7, etc., should cross *CD* as nearly as possible at right angles to ensure accurate division.

Experience and practice will show the best construction for each particular case—*i.e.*, at what angle to draw *CE* and what length to mark off for the division points, 1, 2, 3, 4, etc.

THE SCALE LINE

In constructing a scale, bear in mind :—

(*a*) That it should be of sufficient length to enable measurements to be taken off the map without frequent repetition. For this reason it should be between 4 in. and 6 in. in length.

(*b*) It must show the most convenient divisions of units : tens, hundreds, or thousands, as the case may be.

(*c*) For simplicity in taking measurements, the major divisions of the line are always to the *right* of the zero point. These divisions are usually called Primaries. The minor divisions of one primary division are to the *left* of the zero. These are called Secondaries.

For simple tactical sketches the primaries are always 1 in. long, and the scale will normally be of 100 or 200 yards to 1 in. This is easy to construct on a sheet of the Field Service Message Book (A.B. 153).

(*d*) Keep the scale simple. Elaboration is unnecessary (cf. Figs. 7, 8, 9).

EXAMPLE 1.—Construct a scale of yards for a map showing 4 ins. to a mile.

Here, 4 ins. = 1,760 yds.

So a convenient length would be 2,500 yds.

$$2500 \text{ yds.} = \frac{4 \times 2500}{1760} \text{ ins.} = 5{\cdot}68 \text{ ins.}$$

CONSTRUCTION.—Draw a line 5·68 ins. in length and divide it into five equal parts, each representing 500 yds.; subdivide the part on the left into five parts, each representing 100 yds. Number the divisions as in Fig. 7.

(Note that 0 is placed on the first division of the line.)

$$\text{R.F.} = \frac{4 \text{ ins.}}{63360 \text{ ins.}} = \frac{1}{15840}$$

EXAMPLE 2.—Construct a scale of 200 yds. to 1 in. 4 in. is a suitable length for a sheet of A.B.153.

4 in. = 800 yds.

$$\text{R.F.} = \frac{1}{200 \times 3 \times 12} = \frac{1}{7200}$$

Each primary division will represent 200 yds. A convenient sub-division of the left-hand primary is 25 yds.; therefore it should be divided into eight equal parts as in Fig. 9.

EXAMPLE 3.—The R.F. of a foreign map is $\frac{1}{100000}$. Construct a scale of miles and furlongs for the map.

1 in. on map = 100,000 ins. on ground.
(roughly $1\frac{1}{2}$ miles).

Therefore 9 miles would give a line about 6 ins. long.

$$9 \text{ miles} = \frac{9 \times 63360}{100000} = 5{\cdot}7 \text{ ins.}$$

CONSTRUCTION.—Draw a line 5·7 ins. long and divide it into nine equal parts, each showing 1 mile; subdivide the portion on the left into eight equal parts, each representing 1 furlong. Number as in Fig. 8.

COMPARATIVE SCALES

Comparative Scales are those which have exactly the same R.F. but which are differently graduated. Thus one may show yards, and the other metres.

Scales of yards have already been explained. Scales of metres are constructed in exactly the same manner.

EXAMPLE 4.—Construct comparative scales of yards and metres for a map whose R.F. is $\frac{1}{15840}$.

These scales can both be drawn on one line, but it is better to draw two separate scale lines, one above the other, for easy reference.

1 in. on map represents 15,840 in. or 440 yds.

1,000 metres = 1,094 yds.

Therefore 1 in. on map represents $\frac{440 \times 1000}{1094}$ metres.

$$= 405 \text{ metres.}$$

Thus a line representing 2,500 metres will be a convenient length.

$$2{,}500 \text{ metres} = \frac{2500}{405} \text{ ins.} = 6{\cdot}17 \text{ in.}$$

CONSTRUCTION.—Draw a line 6·17 in. long and divide it into five equal parts, each representing 500 metres. Divide the left-hand primary into ten secondaries, each of 50 metres, as illustrated in Fig. 12.

The scale of yards should be 5·68 in. long and constructed in a similar manner, each primary representing 500 yds. (Fig. 7).

TIME SCALES FOR MARCHING, MOTOR TRANSPORT, ETC.

Question 1.—Construct a scale of distances covered by a battalion marching 3 miles an hour, showing intervals of 10 minutes.

R.F. of map $= \frac{1}{25000}$ (2·53 in. to 1 mile).

Solution.—3 miles an hour = 5,280 yds. In 10 minutes the distance covered is $\frac{1}{6}$ of 5,280 = 880 yds.

Then a line representing 2 miles would be $2{\cdot}53 \times 2 = 5{\cdot}06$ in.

2 miles will be covered in $\frac{2}{3}$ of an hour = 40 minutes.

Draw a line 5·06 in. long and divide it into 4 equal parts (4 distances of 880 yds. = 2 miles—an arbitrary distance). Each part will then represent 10 minutes' marching. (See Fig. 11.)

Question 2.—Construct a scale of distances covered by a motor lorry travelling 15 miles an hour, showing intervals of 5 minutes.

R.F. of map $= \frac{1}{80000}$ (1·26 miles to 1 in.).

Solution—15 miles an hour. (Do not bring to yards, as travelling rate is fast.)

Then 15 miles $= \frac{15}{1{\cdot}26} = 11{\cdot}9$ ins.

Draw a line 5·95 in. long and divide it into 6 equal parts (6 lots of 5 minutes in half an hour).

N.B.—Number the second vertical "0" and the vertical line on either side of it "5 minutes." (See Fig. 13.)

SCALES ON FOREIGN MAPS

So long as the R.F. is given, a scale of English measure can be constructed for a foreign map.

The following tables are useful :—

(i) Used on French, German and Belgian Maps.

100 centimetres	=1 metre.
1,000 metres	=1 kilometre.
1 metre	=39·37 in.
1 Km.	=1093·63 yds.
Approximately, 8 Km.	=5 miles.
11 yds.	=10 metres.

(ii) 1 Russian verst =3,500 ft. or 1,167 yds.

DIAGONAL SCALE

This is an elaboration of the plain scale, and is constructed when small secondary divisions of a unit are required.

An example of a diagonal scale is to be seen on the boxwood protractor.

Figs. 16 and 17 show two examples of a diagonal scale.

The construction of such a scale may be stated as follows :—

The plain scale is first drawn showing major and minor divisions (*vide* examples, Figs. 7 to 9).

Through the zero point and the end of the major division to the left of it are drawn two lines parallel, and upwards, at right angles to the scale line.

Along these lines are marked equal distances, of suitable length, to the number of secondary divisions required. These points are joined by lines which are necessarily—from the construction—equal to one main division in length, and parallel to the scale line, and to one another.

Along the top one are marked the equal distances representing one minor division of the scale, and numbered 0, 1, 2, 3, etc., from the zero line—as on the major division to the left of the zero point.

Join up 0, 1 ; 1, 2 ; 2, 3 ; etc., on the bottom and top lines respectively.

Complete the scale as shown in the examples below.

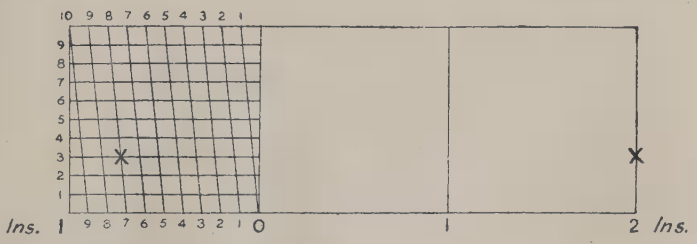
The secondary divisions in the scale shown in Fig. 16 are ten in number, as it is required to measure to 1/100th of an inch. In Fig. 17 the secondary divisions are three, in order to measure to 1 foot (3 ft. =1 yd.).

The figures on the top line are omitted in actual practice. They have been put in in the examples shown to simplify explanation of the construction.

The measurements between the points XX in Figs. 16 and 17 represent lengths of 2·73 inches and 27 yards 2 feet respectively.

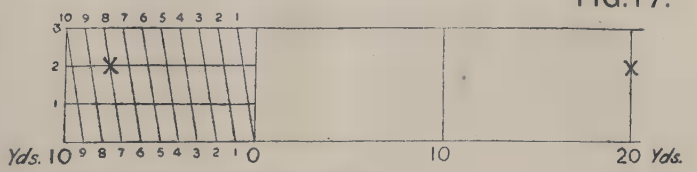
Students are advised to attempt two or three drawings of these scales in order to grasp thoroughly the construction.

FIG. 16.



Diagonal Scale to show 1/100 inch.

FIG. 17.



Scale 10 Yds. to an inch, to shew feet.

EXERCISE II

1. State the scale in words of the following R.Fs.

(*a*) $\frac{1}{63360}$, (*b*) $\frac{1}{15840}$, (*c*) $\frac{1}{21120}$, (*d*) $\frac{1}{10560}$, (*e*) $\frac{1}{10000}$, (*f*) $\frac{1}{25000}$, (*g*) $\frac{1}{7200}$, (*h*) $\frac{1}{7920}$

2. What is the R.F. of the following scales :—

Two ins. to a mile ; 3 miles to an inch ; 1·5 ins. to a mile ; 2 miles to an inch ; 1 in. to 1,000 yds. ; 1 in. to 400 ft ?

3. What is the R.F. when—

(*a*) $1\frac{1}{2}$ ins. represent 1200 yds.
(*b*) $6\frac{1}{4}$ ins. ,, 1250 yds.
(*c*) 3 ins. ,, 1500 yds.
(*d*) $5\frac{1}{4}$ ins. ,, 1400 paces.
(*e*) $4\frac{3}{8}$ ins. ,, 2100 yds.
(*f*) 3·6 ins. ,, 1920 yds.
(*g*) 1·6 ins. ,, 1760 yds.
(*h*) 5·2 ins. ,, 1430 yds.

4. Give the distances represented by measurements on the map of 3·8 ins., 7·4 ins., 9·5 ins., 8·2 ins., 5·4 ins., 6·5 ins., at the scales of (*a*) 4 ins. to a mile, (*b*) 6 ins. to a mile, (*c*) 2·5 ins. to a mile, (*d*) 3·5 ins. to a mile.

5. From a certain point a church is 1,000 yds. distant, a bridge 2,940 yds., a farm 1,800 yds., and a railway station 3,450 yds. What measurements would represent these distances on maps of (*a*) 2 ins. to a mile, (*b*) 6 ins. to a mile, (*c*) 3 miles to an inch, (*d*) 2·5 ins. to a mile ?

6. What distances will represent $3\frac{3}{4}$ miles, 4,000 yds., 2·8 miles, 2,150 yds., and 5 furlongs, on maps whose R.Fs. are (*a*) $\frac{1}{10560}$, (*b*) $\frac{1}{10800}$, (*c*) $\frac{1}{100000}$, and (*d*) $\frac{1}{15840}$?

7. Along a road, on a map R.F. $\frac{1}{10560}$, farms are marked at intervals of $2\frac{3}{4}$ ins., $4\frac{1}{2}$ ins., $\frac{7}{8}$ ins., and 3·8 ins. In what time would each of these distances be traversed by (*a*) Cavalry at 10 miles per hour, (*b*) Artillery at $8\frac{1}{2}$ miles per hour, (*c*) Infantry at 3 miles per hour ?

8. A railway is shown on a map R.F. $\frac{1}{2500000}$, and stations are marked at intervals of $2\frac{7}{8}$ ins., 1·6 ins., $4\frac{1}{4}$ ins. and 5·4 ins. What times would be taken by trains travelling between these stations at (*a*) 15 miles, (*b*) 24 miles, and (*c*) 40 miles per hour ?

9. Make a scale of yards for the following R.Fs. :—

(*a*) $\frac{1}{15840}$, (*b*) $\frac{1}{21120}$, (*c*) $\frac{1}{31680}$.

10. By using the scales of yards on the Service Protractor make scale lines for :—

(*a*) 6 inches to a mile.

(*b*) 5 inches to a mile.

Give the R.F. in each case.

11. Two houses are shown $3\frac{1}{8}$ ins. apart on a map. A man walking at 3 miles per hour travels from one house to the other in $15\frac{5}{8}$ minutes. State the scale of the map, and give the R.F.

12. A boat travelling downstream at 10 miles per hour passed between two bridges in 39 minutes. If the bridges are shown $1\frac{5}{8}$ ins. apart on the map, what is the scale of the map ?

13. The "Field Service Pocket Book" gives the space needed for camps as follows :—

(i) Cavalry Regiment, 161 yds. by 150 yds. ; (ii) Infantry Brigade, 280 yds. by 150 yds. ; (iii) General Hospital, 400 yds. by 250 yds.

What space would represent each of these camps on maps, (*a*) 4 ins. to a mile (*b*) $\frac{1}{10560}$, (*c*) $\frac{1}{2500}$, (*d*) 2·5 ins. to a mile.

14. If a foreign map shows a scale of 5 centimetres to a kilometre, state the R.F., and draw a scale of yards to use with the map.

15. Supposing that infantry march at a rate of 3 miles per hour and cavalry at 4 miles per hour, draw comparative scales of time for both arms (R.F. $\frac{1}{31680}$).

16. On a Turkish map with a scale of " berris " the distance between two points is 13·4 berris. If a berri = 1,823 yds., state the distance in miles between the points.

17. Construct a scale of distances covered by a despatch rider travelling 25 miles an hour, showing intervals of 5 minutes.

18. Construct a scale to be used by a battalion marching $3\frac{1}{2}$ miles an hour, showing intervals of 10 minutes.

EXERCISE III.—SCALES

A.—Questions set on Plate D.

1. From 583098, how long would it take a cyclist travelling at 12 miles per hour to reach the road junction at 492054 ?

2. If a patrol were sent from 583098 along the road to 605057 (road junction), in what time would they do the journey at $2\frac{1}{2}$ miles per hour ?

3. What are the ranges from 583098 of the following road junctions :—

(*a*) 598039. (*b*) 547073. (*c*) 503047.

4. An aeroplane flying in a straight line passed over Nelson House (604104) and Brown's Farm (494054), travelling at 225 miles per hour. In what time did it cover the distance between the points ?

5. In what time would a train travelling at 25 miles per hour cover the length of railway line shown on the map ?

6. A cavalry patrol travelling at 10 miles per hour is on the road at 490055 at 9 a.m., and moves along the road by way of Hood to 610038. At what time will it reach this last point ?

7. Construct for the map a time scale for infantry travelling at 3 miles per hour.

8. A party at 610053 has to proceed by road via Barham to Horden (495103). If the rate of travelling is $2\frac{1}{2}$ miles per hour and there is a rest of 10 minutes at the end of each hour, how long will the journey take ?

9. A motor cyclist at the cross-roads 583098 has to travel to 547038. How long will he take at 20 miles per hour ?

B.—On Fig. 5 ($\frac{1}{25000}$).

10. What is the distance in yards along the road from 600006 to 630019 ?

11. What is the range in yards from 620010 of :—(*a*) The Priory. (*b*) The Mill. (*c*) Hill House ?

12. How long would it take troops moving at 3½ miles per hour to travel along the road from 626000 to 623020 ?

13. On the range card for a machine gun at the north corner of West Wood, what ranges should be shown for :—(*a*) Cross-roads at the Priory ; (*b*) Cole's Farm ; (*c*) The Mill ?

14. For this map ($\frac{1}{25000}$) make a time scale for troops marching at 2½ miles per hour.

15. What is the distance between the bridge near the Mill (in 6000) and the bridge in 6200 (*a*) in a direct line ; and (*b*) along the line of the stream.

C.—On Plate F (R.F. $\frac{1}{10560}$).

16. From the point *A* what are the ranges to *G*, *Q* and *H* ?

17. Assuming that sound travels at 1,100 ft. per second, how long after a shot is fired at *G* will the report be heard at *H* ?

18. What is the total length of road shown on this map ?

19. A battalion had to hold a front extending from *G* through *P* and *Q* to *H*. What was the extent of this front ?

20. Make a scale of yards for this map ($\frac{1}{10560}$) and from your scale line measure the distance in yards between *D* and *H*.

D.—On Plate A.

21. How long would it take a train to travel from Worplesdon Station (4274) to Farncombe Station (4164), at an average rate of 20 m.p.h. in the open, and 10 m.p.h. in the tunnel, allowing 3 mins. for a stop at Guildford ?

22. A party marches from 421710 by the main road through Guildford, to the road junction 426654 ; it then returns via Compton 3966, the road junction 405680, and along the main road to its starting point. At 2½ m.p.h., in what time should the march be completed ?

23. A cyclist orderly is sent from 437705 with messages for posts at 440726, 433724 and 417724 respectively, travelling by the most direct route, and returning to 437705. If his speed is 12 m.p.h. on main roads and 8 m.p.h. on all others, in what time should he return ?

24. A lorry moving at an average rate of 15 m.p.h. leaves the cross-roads 456646 and travels by the main road via Shalford and Guildford to the road junction 403722. If it started at 10 a.m., when should it reach its destination ?

25. A mounted patrol left the road junction at Fairland's Farm (4072) and travelled via Worplesdon to the road junction 434747, thence southwards along the main road to 437702, from which it returned direct to Fairland's Farm. In what time should it complete the journey, travelling at an average rate of 8 m.p.h. ?

CHAPTER V

HILL FEATURES

THE representation of hill features on a map is a matter of great importance, and an explanation of the chief method is given in the following paragraphs.

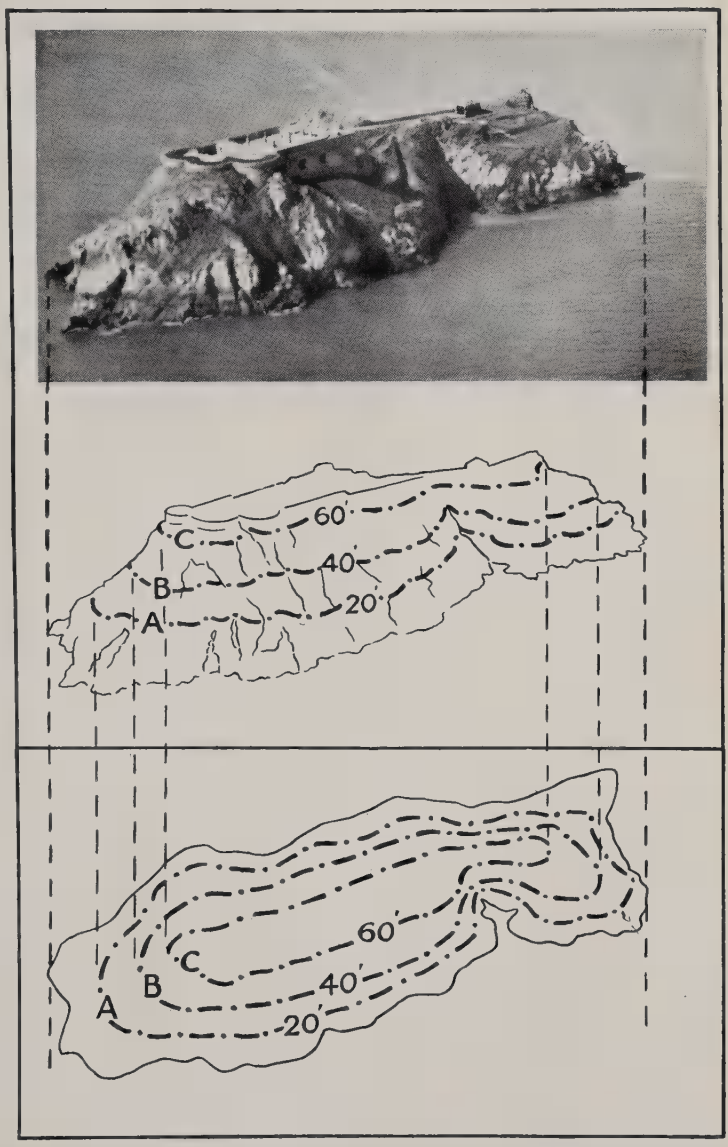
The photograph in Fig. 18 shows an island, the outline of which is given in the map at the bottom of the page; between the two is what may be called a block model of the island, corresponding to the photograph.

Suppose now that the level of the sea were to rise 20 ft.—the water would mark out a line like that shown as *A* on the model; this line would actually join all points on the land which were at a vertical height of 20 ft. above sea-level.

Another rise of the water by 20 ft. would mark out the line shown on the model as *B*, which joins all points 40 ft. above sea-level. In a similar way, a third rise of yet another 20 ft. would give the line *C*, which indicates a level of 60 ft. above the sea. As the highest point on the island is about 75 ft. high, it is evident that a further rise of the water by 20 ft. would completely cover the island.

If now the lines *A*, *B*, and *C* marked out on the model were viewed from above, just as the island could be viewed from an aeroplane vertically above it, then these lines would appear in plan as shown in the map at the bottom of the page. Such lines are called *contours*, and they help to give some idea of the relative height and shape of the land. (*Note.*—In this map the details of the buildings on the island have been omitted to ensure clearness.)

FIG. 18.



[*Photo : Aerofilms Ltd.*

About *contour lines* it should be noted :—

(*a*) Each contour is an imaginary line running along the ground at some fixed height above sea-level.

(*b*) Each contour is at a fixed vertical height above the other—in the case just considered each was 20 ft.—and this fixed height is called the *vertical interval* (usually written V.I.).

(*c*) The horizontal distance between adjacent contours is known as the *horizontal equivalent* (usually written as H.E.).

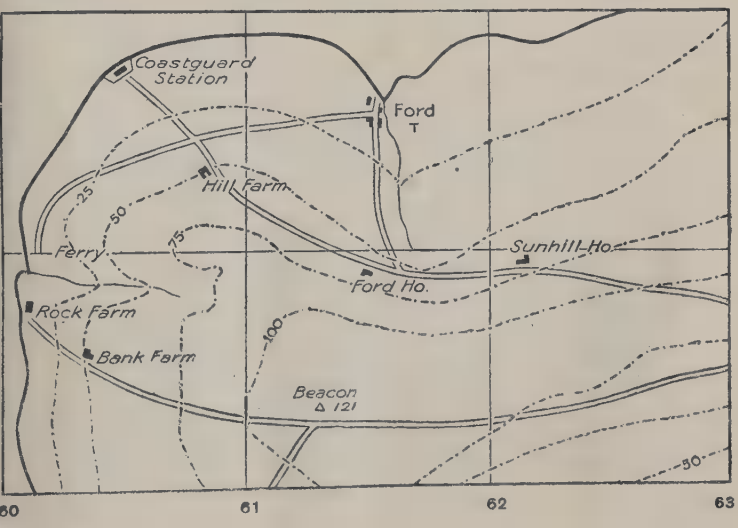
From contours the following can be found :—

(*a*) The height of the ground above mean sea-level.

(*b*) The Shape of the ground.

(*c*) The Slope of the ground.

FIG. 19.



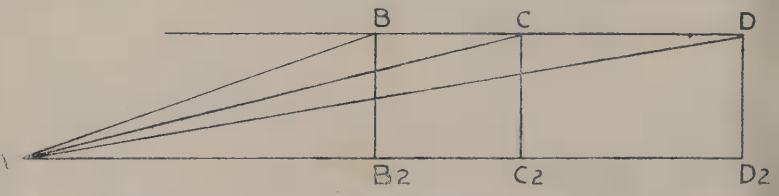
This simple introduction to the use of contours will help to explain Fig. 19, which shows a stretch of coastline from which the land rises to a height of over 100 ft. The highest part is the Beacon which stands near one end of the ridge at a height of 121 ft.

The contours in this case have a *vertical interval* of 25 ft. On looking at the map it will be seen that the contours are at varying distances apart in plan ; two examples of this will be considered :—

(*a*) From Bank Farm to Rock Farm.

(*b*) From Hill Farm to the Coastguard Station.

FIG. 20.



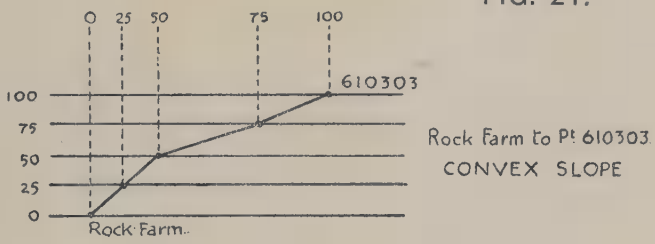
In each case there is a fall of 50 ft., but in (*a*) the horizontal distance is shorter than in (*b*) ; hence the slope in the first case is steeper than that in the second. The point to be noted is that the steeper slope in (*a*) is indicated by the fact that the contours in plan are much closer together than in case (*b*).

Fig. 20 illustrates this principle graphically. *AB* is a steeper slope than *AC* ; and the horizontal distances AB^2 and AC^2 represent the relative distances apart that contours would be mapped for these slopes—it can be seen that the contour lines for the steeper slope would be nearer together than the other pair. Also, the more gentle slope *AD* would give a still greater distance AD^2 between the corresponding contours.

CONVEX AND CONCAVE SLOPES

From what has already been said it will be fairly obvious that where contours are shown at regular intervals apart the slope will be *uniform*; but this seldom occurs in practice.

FIG. 21.



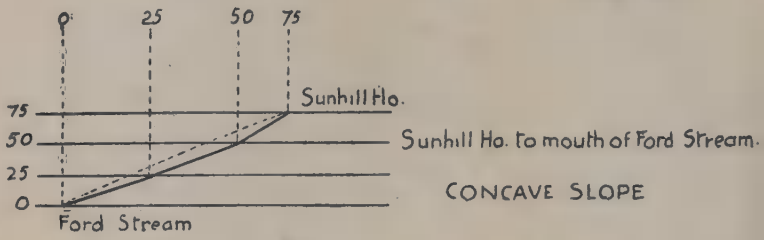
Imagine a journey along the road from Rock Farm up the steep slope to Bank Farm; from thence up the gentler slope to the point 610303, where the height is 100 ft.

Fig. 21 shows how the contours correspond with the slope of the road; this kind of slope, where a direct line of sight from the top to the bottom is interrupted by the ground is said to be *convex*.

It should be noted that in the simple convex slope the contours are closer together at the bottom of the slope than they are at the top. The sketch will also show that in the case of a convex slope there will always be a certain amount of ground hidden from view, which cannot be controlled by rifle fire from the top of the slope—this is called "dead ground."

The opposite type of slope is seen in the direct slope between Sunhill House and the mouth of Ford Stream (616317).

FIG. 22.

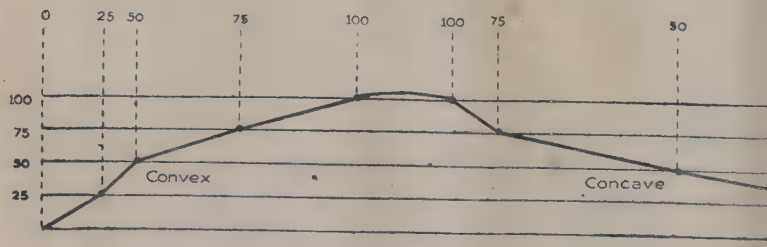


Here the slope near the top, where the contours are closer together, is steeper than it is in the lower portions, where they are further apart, so that no ground interrupts the direct line of sight from the top to the bottom. In this case the slope is said to be *concave*.

(The outline of the hill slope which is used in these diagrams is called a *section* and a note on section drawing is given in the next chapter.)

A simple illustration of both concave and convex slopes is shown in Fig. 23, which is a section along the line of the south edge of Fig. 19. The diagram should be compared carefully with the contours on the map.

FIG. 23.



Section along the south edge of Fig. 1

The slope from the coast to the highest point (614300) is certainly *convex*, as shown by the sharp rise at the lower part of the hill and the comparatively gentle slope towards the top—thus ensuring that the line of sight from top to bottom will be interrupted. The diagram shows this clearly enough, but the student must learn to judge these cases without drawing a section.

The slope from the top towards the east is certainly *concave*, the slope near the top being steeper than that at the bottom, and the line of sight is not interrupted.

These simple examples should be studied carefully, and then applied to examples on other maps. Best of all, take your local ordnance map and select some fairly prominent point on a hill; determine as well as you can from the map the nature of the slopes between this prominent point and a number of selected places. Then take up your position at the chosen point and check your result by the simple test of visibility.

EXERCISE IV

A.—On Plate D.

1. Give the heights of the contours on the map that cut the line of road from the junction in 6005 to a point north of the Inn at Nelson.

2. What vertical height is represented by the ring contour shown north of Longton?

3. An aeroplane flying horizontally passes 500 ft. above the road at the Inn at Nelson. At what height will it pass over the 360 trig. point in 5504 and over the ground level at the Abbey 4999?

4. A man standing on the road at 596072 finds that he is on a horizontal line with the top of the spire of Deep Church. If the ground level at the Church is 245 ft., what is the height of the spire?

5. Is the slope between the following pairs of points concave or convex?

(*a*) Pt. 420 and Pt. 360.

(*b*) Cross-roads in 5403 and the road junction in 5201.

6. Transport at the road junction in 4905 has to move by the easiest road to the road junction in 6005. From observation of the contours on the map, suggest what road should be followed.

7. If a man is standing at the cross-roads (Nelson) in 5809, how far is he likely to be able to see along the roads which extend east and west of him?

8. What is the nature of the slope between :—(*a*) Pt. 360 and 580020 ; (*b*) Pt. 420 and 570060.

B.—On Plate A (Guildford Map).

9. What is the height of the ring contour in 4272 ?

10. State the heights of the small ring contours in (*a*) 4567 and (*b*) 4465.

11. On a line between the spot level 265 in 4268 and Road Junction 705680, is the slope concave or convex ?

12. What is the nature of the slope between the 265 spot level in 4268 and the Ring Contour in 4269 ?

13. What is the nature of the slope between spot-height 144 (433727) and spot height 145 (441731) ?

14. (*a*) What is the nature of the slope between spot height 405 (4467) and the river at Shalford ? (*b*) between road junction at 483687 and the houses at 471695 ?

15. An aeroplane passing over 423744 at a height of 600 ft. vertically above it, keeps on a horizontal course. At what height will it pass over the 326 spot level in 4167 ?

16. Keeping on a horizontal course an aeroplane passes 400 ft. vertically above the road at the 125 spot level in 4673. At what height will it pass over spot height 405 in square 4467 ?

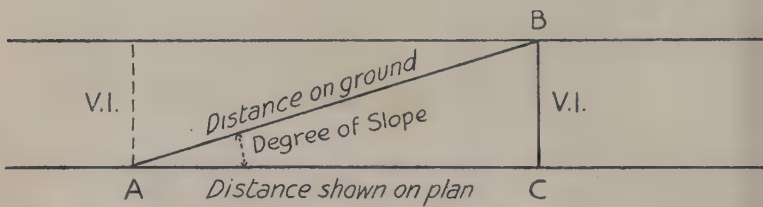
CHAPTER VI

HILL FEATURES—continued

In the last chapter the subject of slopes was dealt with in a general way. Some aspects of this will now be examined in more detail.

Fig. 24 shows two points *A* and *B*, which are on adjacent contours on a map; the distance actually mapped is *AC* and *not AB*. The map-maker can calculate the length of *AC* when he has measured the length *AB* and the angle *BAC*.

FIG. 24.



HORIZONTAL EQUIVALENT.

The distance *AC* is called the *horizontal equivalent* or more usually the H.E.

The angle *BAC* gives *the degree of slope* which is, of course, a measure of the steepness. In map reading it may be necessary to find from the map the *degree of slope*, or, more usually, the *gradient* which is expressed as a fraction—*e.g.*, $\frac{1}{20}$.

GRADIENTS

To find the gradient between two points on a map is not difficult. The distance between the two points must be measured—either directly or along some particular road, as required ; this will then be the horizontal distance, and the vertical interval will be the difference in height between the points.

Suppose two such points were found to be 3,000 ft. apart, and the vertical interval between them was 75 ft. ; then the gradient could be found easily.

$$\text{Gradient} = \frac{75}{3000} = \frac{1}{40}$$

(Note that both measurements are in the same units—feet.)

Or otherwise—

A rise of 75 ft occurs in a horizontal distance of 3,000 ft.

∴ a rise of 1 ft. occurs in a horizontal distance of 40 ft.

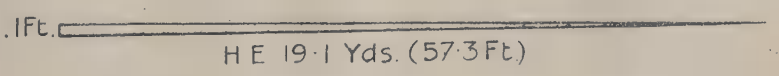
Gradient $= \frac{1}{40}$.

Generally speaking—

$$\text{Gradient} = \frac{\text{V.I.}}{\text{H.E.}}$$ (both expressed in the *same units*).

THE DEGREE OF SLOPE

FIG. 25.



It can be proved that to ascend a slope of 1° until one reaches a point 1 ft. vertically above the starting point, it will be necessary to walk a distance of 57·3 ft.—*i.e.*, the H.E. shown in Fig. 25 will be 57·3 ft. for a vertical interval of 1 ft.

More often 60 ft. is taken as an approximate value for 57·3 ft., and the following results are obtained :—

1° of slope	=	a rise of 1 in	60,	*i.e.*,	a gradient of	$\frac{1}{60}$
2° ,,	,,	=	,,	2 ,,	60,	,,	,,	$\frac{1}{30}$
3° ,,	,,	=	,,	3 ,,	60,	,,	,,	$\frac{1}{20}$
4° ,,	,,	=	,,	4 ,,	60,	,,	,,	$\frac{1}{15}$

If the gradient be known the degree of slope can be found from the results already obtained.

$\frac{1}{60}$ represents a slope of 1°
$\frac{1}{30}$,, ,, 2° } obviously { $\frac{1}{60}$ of 60° = 1°
$\frac{1}{30}$ of 60° = 2°

So for $\frac{1}{15}$, the slope is $\frac{1}{15}$ of 60°, *i.e.*, 4° of slope.
and for $\frac{1}{12}$, ,, ,, $\frac{1}{12}$ of 60°, *i.e.*, 5° ,,

This useful rule gives results approximately correct for angles up to 10°.

The following formula is sometimes used for finding the degree of slope, but those who have mastered the foregoing will have no need of it.

$$\text{Degree of slope} = \frac{\text{V.I. (in feet)}}{\text{H.E. (in yds.)}} \times 19{\cdot}1.$$

$$\text{or } \frac{\text{V.I. (in feet)}}{\text{H.E. (in feet)}} \times 57{\cdot}3.$$

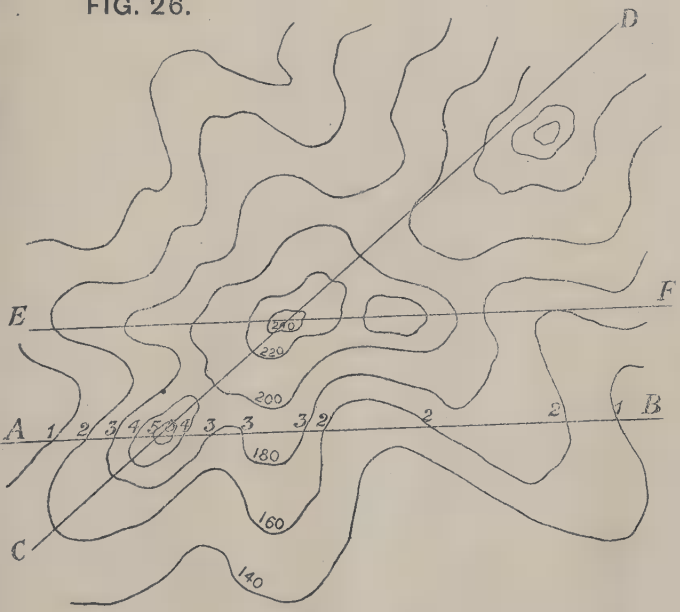
This last, taking the approximation of 60 for 57·3, is the same as the result already reached.

SECTIONS

A section is a representation of the surface that would be exposed if a hill were cut through in any given direction by a vertical plane. A section, therefore, shows heights and depressions, and may be used to decide the nature of a slope, etc., though there are quicker ways of deciding such points. Everyone should be able to draw a section, as it proves one's ability to understand a contoured map.

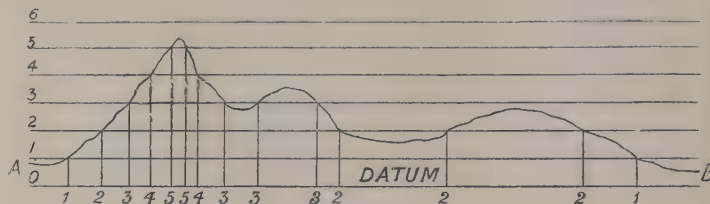
In drawing a section it is customary to exaggerate the heights, generally six times. The heights are so small in proportion to the distances, that the slopes

FIG. 26.



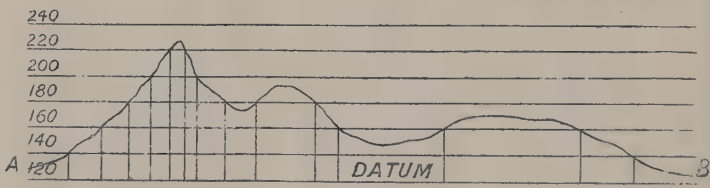
Scale $\frac{1}{10560}$ *V.I 20'*

FIG. 27 A.



Section on A B. H:D as 6:1

FIG. 27 B.



Section on A B H:D 6 1

would not be sufficiently clear. So that in making a section it is generally stated that H : D :: 6 : 1, which indicates that Heights are to Distances as 6 is to 1.

To Draw a Section on any Given Line.

In Fig. 26 make a section on the line *AB* (V.I. 20 ft. Scale 6 in. to a mile).

If H : D :: 6 : 1, the vertical heights will have to be 20 ft. × 6 = 120 ft.; 120 ft. at 6 in. to a mile will be represented by $\frac{3}{22}$ in. (·13 in.). So the section lines will be drawn ·13 in. apart.

Next, take a piece of paper and lay its edge exactly along the line on which the section is required and with a pencil tick off every contour cut by it, and number them, marking the lowest contour 1; and take care that each time the same contour cuts the line it gets the same number. Now transfer these marks to the Datum (or bottom line of the section), and on each of them erect a perpendicular to meet the section line bearing the corresponding number. Join the heights so found, and you have your section (Fig. 27A).

If preferred, in drawing the section the actual heights of the contours can be inserted (Fig. 27B).

Drawing a section requires care. In following a line across a map, particularly if it crosses under-features, cols, etc., a beginner is sometimes puzzled to say whether he is going uphill or downhill. The water-courses will prove an unfailing guide. By observing which way the streams flow, mistakes can be avoided.

EXERCISE V—GRADIENTS

A.—On Plate D.

1. What is the gradient on the road between 591081 and 600064?

2. Find the road gradient between 547073 and 570060.

3. In a line of sight from Pt. 420 to Pt. 360, what is the gradient?

4. On the line of march from 492054 via Hood to the road junction in 5903, what is the steepest gradient? What appears to be the most level part of the road?

5. An aeroplane when 500 ft. above Pt. 420 is observed from Pt. 365. What is the angle of elevation from Pt. 365?

6. What is the average gradient on the road between the points 500063 and 537087?

7. If the road junction in 5004 has a spot level of 230 ft., while the road at 542042 has one of 348 ft., what is the average road gradient between the points?

8. An observer at Pt. 360 noted that a line of sight to an aeroplane vertically above Pt. 420 gave an angle of elevation of 2°. At what height was the machine above Pt. 420?

9. If the road junction in 5600 is at a level of 225 ft., what is the gradient between it and a point on the road at 550025?

10. A plane flying 200 ft. above the road junction in 5004 (230 ft.) lands at 520030 (195 ft.); find the gradient of its descent.

B.—On Guildford Map (Plate A).

What is the gradient between the following points ?

11. Pt. 96 in 429735 and Pt. 144 at 432727.

12. Pt. 114 at 438654 and Pt. 135 at 444746.

13. Pt. 140 in 4165 and Pt. 127 at 426654.

14. Pt. 117 in 4172 and Pt. 204 in 4271.

15. Pt. 334 in 3964 and Pt. 371 in 3866.

16. What is the gradient in a direct line between trig. point 205 in 3971 and Pt. 134 in 4070 ?

17. A man at Pt. 286 in 4170 sees an observation balloon 200 ft. above Pt. 221 in 3871. What is the gradient of the line of sight ?

18. A plane 100 ft. above Pt. 134 in 4070 lands at 425720 (148 ft.). What is the average gradient of its descent ?

EXERCISE VI.—SECTIONS

1. Make a section on the line *CD* (Fig. 26).

2. Draw a section on the line *EF* (Fig. 26).

3. On Plate F, scale 6 in. to a mile, V.I. 50 ft., make a section of the roadway entering the map below *C*, along its length to the point where it leaves the right-hand side of the map.

4. On Plate F (as in No. 3) make a section on the line *E* to *G*.

5. Plate D: Make a section on the line from 593098 to 522018.

6. Plate D: Make a section of the line between 520080 and 600000. (This will illustrate the *col* in 5603.)

7. Plate D: Prepare a road section showing the road between 491054 and 584032.

8. Plate A: Make a section on the line between Worplesdon Station (4274) and the road junction near Fairland's Farm (403722).

9. Plate A: Prepare a section on the line from Pt. 171 in 4767 to the road at 475702.

10. Plate A: Make a road section for the main road from Pt. 505 in 3867 until it reaches the bridge over the river at Guildford.

CHAPTER VII

HILL FEATURES—concluded

VISIBILITY

From a military point of view, the ability to determine accurately from the map whether a point or tract of ground is visible from another point is of first importance.

Ability comes with practice.

The student should decide in the class-room what places and portions of ground are visible or invisible from a particular spot, and mark them so on the map; then take the map out to that particular spot on the ground, set it, and see if his decisions are correct.

Begin with simple slopes.

Convex and concave slopes have been dealt with. But it is important to be able to determine from the map to what distance *the dead ground in front of* a convex slope extends.

It should be remembered that ability to determine visibility by *studying contours* is what is required. Frequently there is no time to draw sections or make calculations, even the simplest.

But in order to acquire this ability other methods should be practised. These are—

(*a*) By a proportion sum.

(*b*) By the rise and fall of the line of sight.

(*c*) By comparison of gradients.

(*d*) By drawing a section.

In (*a*) ascertain if any feature is likely to interrupt the visibility. Measure the distance on the map between the two points under consideration—say,

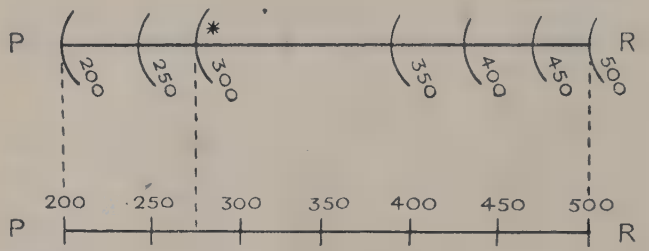
3 in. between *R* (high) and *P* (low); and also the distance from one of these points, take *P* (low), to the likely point of interruption marked *, suppose $\frac{3}{4}$ in.

The point of *interruption* is 2 contours above *P*. Now line of sight from *P* rises 2 contours in $\frac{3}{4}$ in. across the map. ∴In 3 in. across the map the line of sight will rise $\frac{2 \times 3}{\frac{3}{4}} = 8$ contours.

So *R*, to be visible, should be at least 8 contours higher than *P*; but the actual number of contours between them is 6.

∴R is not visible from *P*, for the line of sight from *P* over the point marked * will pass at a height of 2 contours above it.

FIG. 28.



In (*b*) by the rise and fall of the line of sight, refer to the previous diagram.

Divide the line *RP* into as many equal parts as there are number of V.Is. (six). Then the figures on each division line show the height of the several points (which are not to be confused with the figures of the contours).

Compare each contour in turn with the *division-number* near to it, and decide if the contour is higher or lower. If higher, then the land at that spot is *above* this equally-divided line (the line of sight, really),

and visibility *is interrupted.* If lower, then the land is lower than the equally-divided line of sight; consequently the line of sight is not interrupted, and the two places are visible to each other.

In the example shown in Fig. 28, it will be seen that * on the 300 ft. contour is at a point on the divided line where the height marked is less than 300 ft. Therefore, the direct line of sight from *R* to *P* (represented by the equally divided line) will be interrupted by *, and the slope is convex.

In (*c*) by Gradient (refer to diagram in (*a*)):—

(i) *R* to * = a difference of 200 feet.

Distance on ground (referring to scale of map is, say, 3,000 yards.

Then Gradient $= \frac{200 \text{ ft.}}{3{,}000 \text{ yds.}}$ or $\frac{200 \text{ ft.}}{9{,}000 \text{ ft.}}$ or

$\frac{2}{90}$ or $\frac{1}{45}$, which expressed in Degrees $=$ $\frac{1}{45}$ of $60° = 1\frac{1}{3}°$

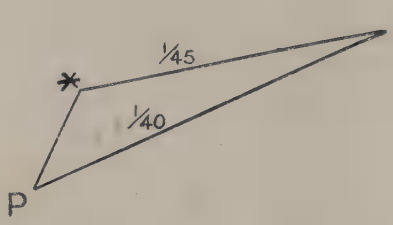
(ii) *R* to *P* = a difference of 300 feet.

Distance on ground (referring to scale of map) is, say 4,000 yards.

Then Gradient $= \frac{300 \text{ ft.}}{4{,}000 \text{ yds.}} = \frac{100 \text{ yds.}}{4{,}000 \text{ yds.}} = \frac{1}{40}$ or $1\frac{1}{2}°$.

So the gradient from *R* to *P* ($\frac{1}{40}$) is steeper than the gradient from *R* to * ($\frac{1}{45}$). Therefore, the point * on the ground interrupts the direct line of sight from *R* to *P*, as shown in Fig. 29, and the two points are not visible from each other.

FIG. 29.



In determining the heights of points on a contoured map, it is first necessary to distinguish which features are watercourses and which are spurs. To do this, *look out for a stream, which denotes a valley, or a ring contour, which denotes a hill.* The features will then follow as spurs and valleys alternately—the direction of the slope changing whenever a contour turns back on itself. When contours do not turn back within the limits of the map, or in doubtful cases, remember that *where contours conform to the shape of each other they are on the same slope ; those that do not conform indicate a change of slope.*

On Plate F, *DA* indicates a continuous slope ; but beyond *A*, on the line *AC*, the contours do not conform to those along *DA*, hence there is a change of slope at *A*. Similarly, *GK* is a continuous slope ; south of *K* the contours begin to turn, and do not conform to those along *GK*, and indicate a change of slope ; in this case the stream indicates a valley, and leaves no doubt as to the nature of the ground.

In the first case the turn of the contours denotes a spur (or salient), while in the latter case the turn marks a re-entrant.

If the points are on the opposite sides of a valley, like *G* and *H* in Plate F, they are of course visible from each other and the general section is concave.

But if another hill, or under-feature, comes between them, it is a question of whether it is high enough to intercept the line of sight from one to the other. If it is, then the general section is *convex ;* if it is not, then the general section is *concave.*

The point should be thoroughly understood, for the question arises frequently as to whether the general section between two points is concave or convex ; the answer lies in the fact whether or not one point is visible from the other.

Section Drawing will often help to solve a question in visibility. Frequently time can be saved, when testing a problem by section drawing, by plotting only the points which are likely to interrupt the line of sight. This is called a *special section.*

To determine whether two points are visible from each other, draw a line between the points, and, starting from the highest, select the spur or feature that is likely to interrupt the line of sight ; then mark the apparent crest of the line of sight.

The apparent crest will be the contour of the intervening feature farthest from the highest point.

Example.—To decide whether K is visible from A (Plate F).

Draw a line from A to K ; the intervening height is the under-feature J ; the apparent crest will be at N (not J).

Method 1.—(a) From A to N the line of sight has fallen two contours in a distance (on the map) of 1·9 in. ; how much will it fall in 1·7 in. (distance from N to K) ?

As 1·9 in. : 1·7 in. : : 2 contours : x

x = 1·8 contours.

Therefore the line of sight falls 1·8 contours from N to K ; but as K is three contours below N, it is below the line of sight, and K is not visible from A.

(*b*) To determine whether *P* (in the same line of sight) is visible from *A*.

A to *N* = 1·9 in., with a fall of 2 contours.
N to *P* = 2·7 in., with a fall of ? contours.
As 1·9 in. : 2·7 in. : : 2 contours : *x*
x = 2·8 contours.

The line of sight from *N* to *P* falls 2·8 contours, and as *P* is only 2 contours below *N*, it is above the line of sight. Therefore *P* is visible from *N*.

METHOD 2.—This method is strongly recommended, as the candidate can see the result clearly recorded on the map. It is also the most useful method, because it helps to solve the following types of question :—

(*a*) Visibility of points.
(*b*) Where a line of sight through a certain point will touch the ground.
(*c*) The amount of dead ground in a line of sight between two points.
(*d*) How much of a certain area of ground may be seen from any particular point.

EXAMPLE (*a*).—The line *AN* represents a fall of the line of sight through a vertical distance equivalent to the height o two contours. This line is then divided into two parts, and each will be a unit length representing a vertical fall in the line of sight equal to the V.I. of one contour; these units are marked along the line of sight *AK* and are numbered. *N* is on No. 4 contour, so that the next divisions will be marked Nos. 3 and 2, as on the map.

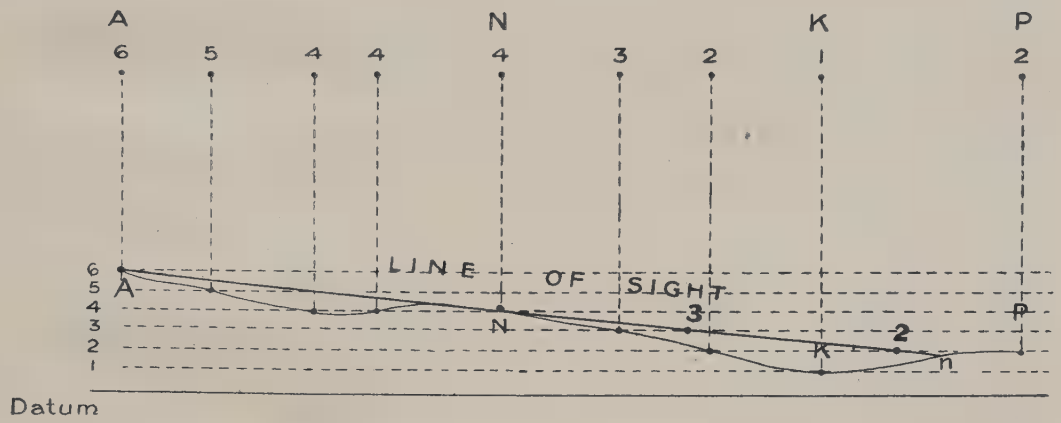
K is on No. 1 contour, but as the line of sight at that point has not fallen through a vertical distance equivalent to this (*i.e.*, two contours from *N* or four from *A*), the line of sight passes above *K*.

∴ *K* is not visible.

(Reference to the rough section shown on Fig. 30 will verify this.)

FIG. 30.

Rough Section on the line A. N. K. P. on Plate F to explain Visibility of Points



EXAMPLE (*b*).—*AP* happens to be in the same straight line as *AK*, and *N* is the intervening feature, hence the work in Example (*a*) will do for this.

The point at which the line of sight has fallen through a vertical distance to the level of No. 2 contour is marked on the map between *K* and *P*, hence when the line reaches *P* it is below the level of No. 2 contour on which that point stands. Hence *P* is above the line of sight from *A*, and is therefore visible.

(This is shown clearly on Fig. 30.)

EXAMPLE (*c*).—*How much dead ground is there in a line of sight from A to P?*

The ground from *A* to *N* is within the range of vision, hence it is necessary to find where the line of sight from *A* to *N* (extended) intersects the ground in front of *P*.

(This is shown by the rough section shown on Fig. 30.)

The work on the map is the same as in (*a*) and (*b*).

From the point marked 2 the line of sight from *A* to *N* continues on to meet the ground which is sloping from *P*. Hence the point at which the line of sight would meet the ground would be about half-way between *P* and the point marked 2; this is shown at "*n*," and *Nn* shows the amount of dead ground.

EXAMPLE (*d*).—*How much of Hill G is visible from the top of a wall, 10 feet high, at E?* (V.I. 20 ft.)

The intervening feature is knoll *J*. Draw lines of sight—from *E* through the extreme edges of the contour, and one through the middle.

The crests of the lines of sight will be at *x*, *y*, and *z*.

The wall at E is 10 ft. above No. 5 contour, while the x, y, and z are on No. 4 contour, therefore the lines Ex, Ey, and Ez each represent a fall of the line of sight through a vertical distance of 30 ft. The most convenient unit to use here is 10 ft., so that if these lines are divided into three parts, each part will approximate to a fall of a vertical interval of 10 ft. Mark these units along the lines.

At x_2 the level reached by the line of sight is $1\frac{1}{2}$ contours (30 ft.) below x and this is the approximate level of the ground at that position on the map; hence the line of sight will meet the ground at x_2.

The other lines of sight will similarly meet the ground at y_2 and z_2. The portion of the hill that would be visible lies above these points, and can be indicated as shown by the dotted line joining them.

EXAMPLE (*e*).—*Is Q visible from R?*

On drawing a line between the points, it will be seen that if the line of sight is at all interfered with, it will be by the crest near E. Now the line of sight falls 1 contour from R to the crest; mark off similar divisions along the line. It will then be seen that while Q is on No. 1 contour, the line of sight passes over it at a height of about $1\frac{2}{3}$ contours, hence Q is below the line of sight and is not visible from R.

EXERCISE VII.—VISIBILITY

A.—On Plate D.

1. A man is at the road junction in 5207. Can he see (*a*) another man at Pt. 365; (*b*) Brown's Farm; (*c*) an observer at 570085 ?

2. An aeroplane vertically above Nelson Church is just visible to a man standing at the road junction in 5207. What is the height of the plane above ground level at the church (345 ft.) ?

3. A scouting party has moved to 590080. Can it from this point see the road junctions at 597039 and 583032 ?

4. At what point can the party at 590080 first observe traffic moving eastwards along the road from Hood ?

5. How much of the road between 504047 and 549990 is visible from a point on the road at 530042 ?

6. From 540030 (255 ft.) are the following points visible :—

(*a*) The Abbey, 4999 ?

(*b*) Longton Church ?

(*c*) An observer at 520000 ?

7. A man is at 560050. How much of the road from a point due north of him to 597045 will he be able to see ?

8. From trig. point 360 an aeroplane is seen vertically above 600105. What is the least height of the machine above ground ?

B.—On Plate A.

9. An observer is at spot height 405 in 4467. Can he see the level crossing at 453665 ; and Warren Farm in 4568 ?

10. Will a man standing at Pt. 134 in 4071 be able to see Fairland's Farm ? Is the farm visible to a man standing at Road Junction 417724 (123 ft.) ?

11. Will Worplesdon Church tower be visible to a man at Pt. 144 in 4372 ?

12. From the Knoll at 401715 can an observer see (*a*) troops on the road at spot height 208 (400705), and (*b*) others on the ring contour 395708 ?

13. From an O.P. on the ring contour at 424694, at what point should it first be possible to see vehicles moving along the road towards Fairland's Farm (4072) from Guildford ?

14. Should traffic on the road about 411727 be visible to an observer on the knoll about 408718 ? Apart from the actual contour of the ground as shown on the map, what obstacle might obstruct the view ?

15. A party at the cross-roads 440725 is marching northwards along the road. At what point will it first get a view of (*a*) Cox's Farm ; and (*b*) the Church at 434732 ?

16. A car is proceeding southwards along the main road from Pile Hill (4374). At what point will the driver first be able to see the woods at Boxgrove (4470) ?

CHAPTER VIII

TOPOGRAPHICAL TERMS

Basin.—(*a*) An area of more or less level ground, such as the bed of a dried-up lake, surrounded or nearly surrounded by rising ground.

(*b*) The area drained by a river and its tributaries.

Col.—An elevated mountain pass connecting two valleys on either side of a mountain range ; a sharp depression in a high ridge of land.

Crest.—The ridge, or topmost edge, of the highest part of a mountain, hill, cliff, or rising ground.

Hill.—An eminence of less altitude than a mountain ; ground which falls away on all sides and is less than 3,000 ft. is generally designated a hill.

Hillock.—A small detached hill.

Knoll.—A low hill or mound ; a detached elevation on the top of a hill.

Nullah or Donga.—A dry water course ; a channel or gully formed by the action of a stream or rapidly-flowing water.

Plateau.—A broad flat area of land on top of elevated ground ; a small tableland.

Ravine.—A deep, narrow depression or fissure, with steep sides in the ground or side of a hill ; a deep, narrow mountain pass.

Re-entrant.—A depression running into a main feature, such as where the side of a hill curves inward.

Saddle.—A geographical feature something like a col, only with a sharper and narrower ridge.

Salient or Spur.—A tongue or spit of high ground jutting out from a mountain or hill ; a projection from a mountain range.

Tableland.—A large area of fairly level elevated land.

Under-feature.—A minor feature of a main feature.

Undulating Ground.—Ground being a succession of marked depressions and elevations like the waves of the sea.

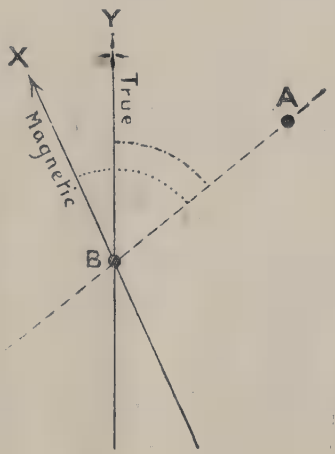
Watercourse.—The channel of a river or stream.

Watershed.—The ridge which separates the basins of two rivers; the dividing line, generally formed by well-marked high ground, separating the drainage areas of two rivers.

TECHNICAL TERMS

Base or Base Line.—A straight line measured on the ground, from the two extremities of which angles are taken in laying down triangles in military sketches or surveys. On the accuracy of the base, or base line, the whole value of a survey depends.

FIG. 31.



Bearing.—The angle a line makes with the true north line is a true bearing. The angle a line makes with the magnetic north line is a magnetic bearing. The angle in each case is measured from north by east and south —*i.e.*, in a clockwise direction.

To explain more fully what is meant by the *bearing* of an object a little more detail is essential.

The magnetic bearing of an object (*A*) from another object (*B*) is the angle which a line drawn from *B* to *A* makes with a line running through *B* in a magnetic N. and S. direction—*i.e.*, the angle *XBA* in Fig. 31.

A true bearing would be the angle made by the line *BA*, with a true N. and S. line running through *B*—*i.e.*, the angle *YBA* in the figure. This angle *YBA* is the true bearing of the object (*A*).

Similarly, *grid bearing* is the angle a line makes with the grid north line.

Contour.—The outline of the surface of the ground above sea-level with regard to its undulations. The outline of a plane surface which would be exposed when a hill or other geographical feature is cut by a horizontal plane. Contours represent a fixed variation of so many feet from those nearest. This fixed variation is termed the Vertical Interval (V.I.).

Form Lines are approximate contours sketched in by eye.

The **Horizontal Equivalent** (H.E.) is the horizontal distance that will correspond to any given degree of slope, the V.I. being fixed; *it is the distance in plan between two contours.*

A **Gradient** is a slope expressed as a fraction; thus a gradient of $\frac{1}{30}$ indicates a rise, or fall, of 1 ft. in every horizontal distance of 30 ft.

A **Section** is a representation of the outline of a hill exposed by its intersection with a vertical plane in any given direction. A plane is a surface ; and if a cutting were made through a hillside, the portion exposed would be a plane surface, and would represent a section of the hill.

A **Datum,** or **Datum Level,** is an assumed level with reference to which heights are measured, or compared, or shown in a section. It is usually, but not necessarily, the lowest point in a sketch.

Hachures are short, disconnected strokes of the pen, by which the shading of hill features may be effected ; the strokes are drawn directly down the slopes.

A **Meridian** is a line drawn true north and south.

A **Magnetic Meridian** is a magnetic north and south line.

Orientation is the term applied to the practice of setting a map or plane table so that the north line points north.

Plotting is the process of laying down on paper field observations and measurements.

Re-section is a method by which a person determines his position on the map by observing the bearings of, or drawing lines from, at least two fixed points.

Triangulation or **Intersection** is the system of accurately fixing the position of important features or points on the area to be surveyed or sketched, by means of a measured base and a chain or network of triangles dependent on it, obtained by the intersection of bearings.

Triangulation is applied to an accurate survey.

Intersection is the term applied to a military sketch where the work is only approximately correct.

CHAPTER IX

THE PRISMATIC COMPASS

Most people are familiar with the four cardinal points of the compass, and the four intermediate points; but Fig. 32 shows the complete marking. From the eight known points it should be simple to put in the eight points midway between them, such as N.N.E. and E.N.E. These should be known by all students, but the remaining sixteen points of the mariner's compass are not so important, though they may easily be remembered because they lie in pairs on either side of the first eight, and in each of them, *e.g.*, N.E. by N., the word " by " is used.

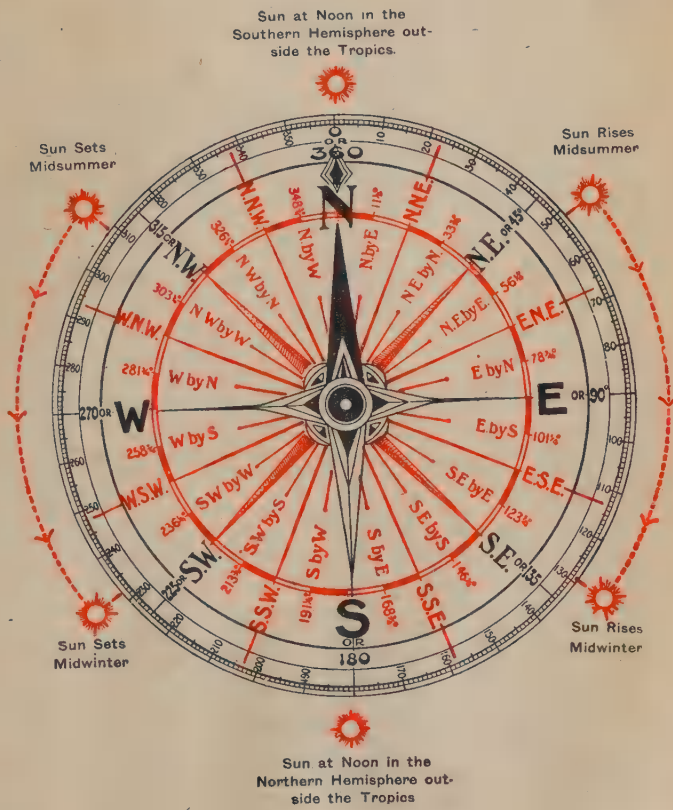
In the Service the most usual method of giving direction is by a bearing in degrees. The compass card is divided into the 360 degrees of the circle, with North as *zero*. This marking is also shown in Fig. 32, and the greater number of divisions makes for accuracy.

THE VARIATION OF THE COMPASS

The compass needle seldom points to the true or geographical north. It points to what is known as the magnetic north. In the British Isles this magnetic north line lies to the west of true north; near London the variation in 1934 was about 12° W. This figure is not fixed; it is decreasing by about 11 mins. each year.

The amount of the variation in any district can be found from the ordnance map, which will give the conventional sign showing the variation, the date, and the yearly rate of decrease or increase. In most parts of India the variation is *east*.

FIG. 32.


Sun at Noon in the Southern Hemisphere outside the Tropics.
Sun Sets Midsummer
Sun Rises Midsummer
Sun Sets Midwinter
Sun Rises Midwinter
Sun at Noon in the Northern Hemisphere outside the Tropics
N
N.E.
E
S.E.
S
S.W.
W
N.W.
N.N.E.
N.E. by N.
N.E. by E.
E.N.E.
E. by N.
E. by S.
E.S.E.
S.E. by E.
S.E. by S.
S.S.E.
S. by E.
S. by W.
S.S.W.
S.W. by S.
S.W. by W.
W.S.W.
W. by S.
W. by N.
W.N.W.
N.W. by W.
N.W. by N.
N.N.W.
N. by W.
N. by E.
0 OR 360
11¼°
33¾°
45° OR NE.
56¼°
78¾°
90° OR E.
101¼°
123¾°
135° OR SE.
146¼°
168¾°
180 OR S.
191¼°
213¾°
225° OR SW.
236¼°
258¾°
270° OR W.
281¼°
303¾°
315° OR NW.
326¼°
348¾°

On gridded maps the amount of the variation from grid north instead of, or as well as, from true north will be shown. True north is indicated, however, by at least one meridian marked on the top and bottom edges. The line joining these points indicates true north.

It is of practical importance to know the variation of the compass in the district where one is working and to understand what effect it has on map work. Beginners would do well to take a number of compass bearings from a certain point on the ground, and then compare them with the grid bearings from the same point as measured on the map; the grid bearings will differ from the magnetic bearings in each case by the amount of the variation. If there is any other difference the reason should be searched for; there may be a compass error, but such practice will be very useful if the early mistakes drive home the lesson that when using the compass care must be taken to avoid the presence of iron—guns, barbed wire, steel helmets, rails, corrugated iron, etc., all affect the reading of the compass.

(The methods of finding true north are described in Chapter XIII. Once a true north line is determined between two points, then a bearing taken along this line will afford a useful check of the variation of the compass.)

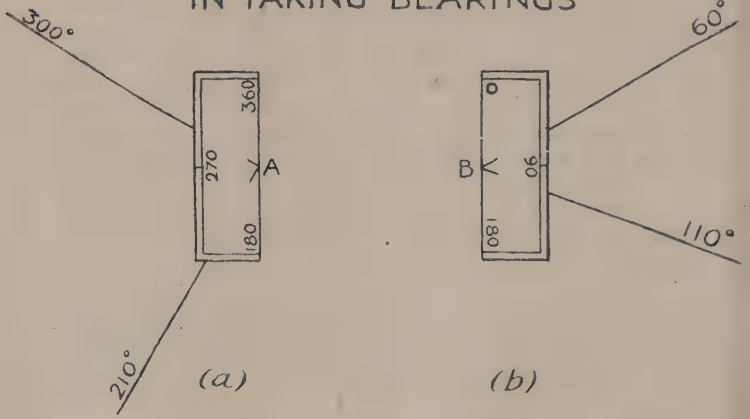
TO LAY OFF A BEARING.

The Service Protractor (Plate E) is generally used for this purpose. Note the marking of the angles on its bevelled edge; the *outer* edge is graduated to show the degrees of the semicircle from 0° to 180°, while inside these is a continuation of the numbers from 180° to 360°. At the mid-point of the *inner* edge is the centre (indicated by an arrowhead) from which these marked angles have been drawn.

This *inner* edge is always laid along the grid north and south line through the point from which the bearing is to be plotted, with the arrowhead at the point. If the bearing is between 0° and 180° the protractor must be to the *right* of the line ; if between 180° and 360° the protractor must be to the left of the north and south line as shown in Fig. 33.

FIG. 33.

USE OF PROTRACTOR IN TAKING BEARINGS



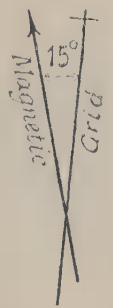
When the protractor is in position, then any bearing already plotted can be read off, but if any particular direction be required, a dot can be marked on the map at the protractor's edge opposite the desired number of degrees, and a line from the centre point through this dot will give the bearing required.

GRID AND MAGNETIC BEARINGS

Grid north is the direction indicated by the north and south grid lines, and, for the sake of simplicity in measuring bearings on a map, grid bearings are used in preference to true bearings. In England Grid north and True north are considered as identical for practical purposes, although this is not strictly accurate, since grid lines are parallel, whereas true north lines converge towards the north pole.

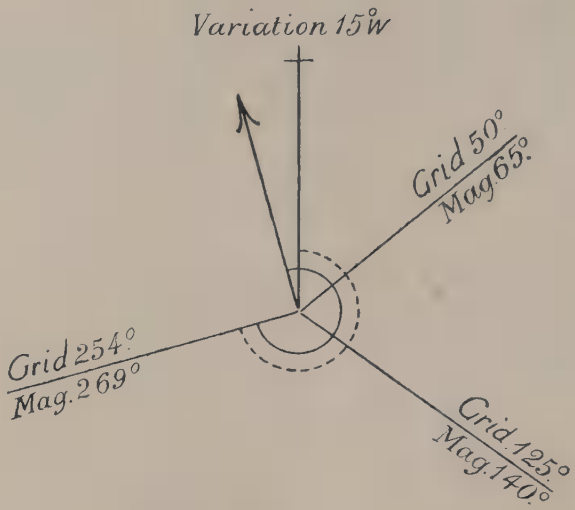
Reference has already been made to the conventional signs used on ordnance maps for the north points. The sign used on field sketches is shown in Fig. 34—a cross-bar for grid north and an arrowhead for magnetic north.

FIG. 34.



When it is required to convert grid bearings into magnetic bearings and *vice versa*, all the necessary work can be developed from the conventional sign as is shown next in Fig. 35.

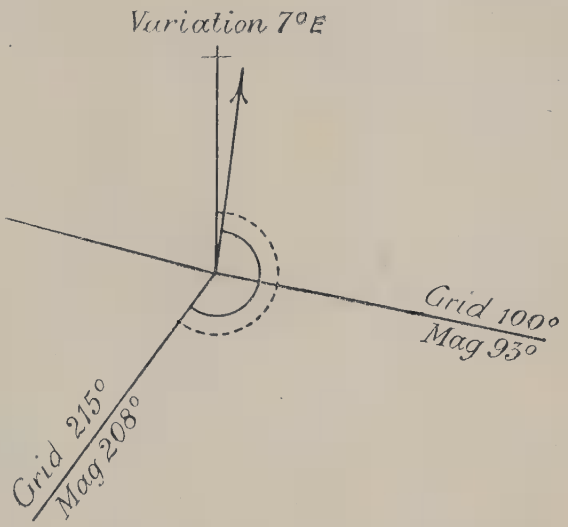
FIG. 35.



From each of the bearings given, it will be seen that the grid bearing as shown by the angle marked out by the dotted line is less than the angle of the *magnetic* bearing marked by the firm line, by the amount of the variation west.

The next case depicts an illustration where the variation is *east*, and here it will be seen that the dotted line which marks out the angle of the grid bearing indicates that it is greater than the magnetic bearing in each case by the amount of the variation east.

FIG. 36.



In any particular case it is but a moment's work to draw or imagine the conventional sign showing the variation, and to make the necessary calculation. There is no need to learn any rule of thumb, and with a little practice the whole thing becomes very simple. In work on a map it is better to change all magnetic bearings into grid bearings. When bearings are taken from a map with a view to giving orders, they must be issued as Grid bearings.

The **Service Prismatic Compass** (Fig. 37) is about 3 in. in diameter, and differs from the ordinary compass in the following ways :—

1. The circular card is attached to the needle, so that the card moves with the needle.

2. It has a metal lid with a glass top and hair line on it, which does duty for a sight vane, and directly opposite to it is an eye-piece (containing a prism) with a slit in it, so that the hair line can be seen; this line of sight would pass exactly over the centre of the card.

3. The card (being larger than in the ordinary compass) is divided into degrees and half-degrees. By means of the prism (which magnifies) the numbers below it can easily be read. If the card were numbered as in the ordinary compass, the number that would appear under the prism would differ from the actual bearing by 180°. To save the trouble of calculation, the numbers on the card which are reflected by the prism are reversed, so that the number which appears under the prism is the actual bearing of the object.

4. There is a small knob on the outside rim of the box under the vane; by pressing this, the card can be prevented from swinging about.

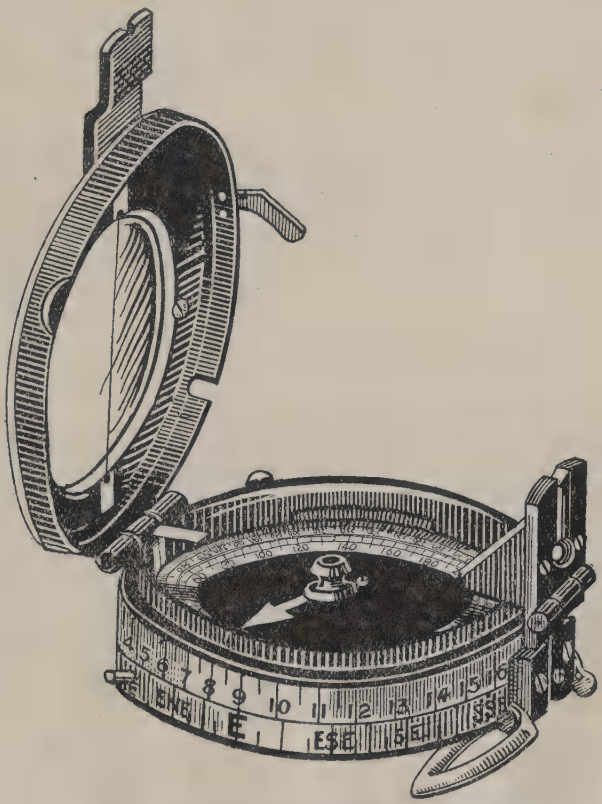
5. For night work the north-pointing arrow-head is luminous.

TO USE THE PRISMATIC COMPASS

Turn up the sight vane and prism and hold the compass out in front of the body towards the object whose bearing is required. When the card has ceased swinging bring the compass steadily to the eye and look through the prism, keeping the compass in a horizontal position all the time. When the hair line is correctly aligned on the object, and the card has come to rest, the correct bearing of the object may be read through the prism.

For night work the north-pointing arrow-head on the card is luminous. There is also a luminous patch on the glass cover of the compass. (See Fig. 37.)

FIG. 37.



The Service Prismatic Compass.

Suppose it is desired to march at night on a bearing of 110°. Before starting out, the glass cover is moved round by means of the milled edge (shown in the sketch) until the notch under the luminous mark is over the figure 11. (The graduations are obviously in tens, for it can be seen that the 9 coincides with East.) The cover is then clamped by means of the screw shown in the diagram at the far side of the compass.

Now in the dark, the compass is held so that the luminous north point coincides with the luminous point on the cover. The required direction (110°) will now be obtained by taking a line from the eye-piece of the prism through the hair line of the sight vane.

INDIVIDUAL COMPASS ERROR (I.C.E.)

Every compass should be tested from time to time, as it may be slightly inaccurate owing to faulty manufacture or rough usage. This should be done by checking the compass reading against the correct magnetic bearing found from a map. The grid bearing should be measured on the largest-scale map available and converted into a magnetic bearing from the information about north points given at the side of the map. The difference, if any, is the I.C.E. and is recorded as so many degrees east or west. A compass error of 2° W. indicates that the particular compass needle points 2° W. of magnetic north.

In practice, readings should be taken on two, or if possible, three, objects clearly visible to the observer both on the map and on the ground, as far away as possible, and equally spaced round the points of the compass. The average error of the readings will be the I.C.E.

NOTE ON VARIATION

It is interesting to know that the real causes of the yearly changes in the amount of variation have not been settled satisfactorily by scientists.

In 1580	the angle	of variation	was 11° 15 mins. E.
In 1657	,,	,,	0° (the magnetic and true north coincided).
In 1814	,,	,,	24½° W.
In 1818	,,	,,	24° 38½ mins. W.
In 1897	,,	,,	16° 44 mins. W.
In 1906	,,	,,	15° W.
In 1920	,,	,,	14° W. in East Anglia and 16° W. in S.W. England and Wales.

Thus it appears that the variation moves like a pendulum from one side of true north to the other, but actually the fact is that the magnetic pole is moving around the north pole of the earth in a wide circular motion which takes nearly one thousand years to complete. At present the needle is returning towards the true north at the rate of about 10 mins. per year. This sort of variation is termed Annual Variation.

In addition there is a Positional Variation, which means that the amount of variation differs according to the locality in any one country. It is governed by the presence of iron in the ground.

When using a compass much care is needed to avoid guns, barbed wire, steel helmets, cap badges, rails, corrugated iron, etc., as their near presence always affects the reading of the compass.

The " dip of the needle " means that if the needle is suspended freely it will assume an inclination or angle to the magnetic equator. For instance, at London the " dip " is 67° N. ; in Dehra Dun (at foot of the Mussoorie Hills, India) the " dip " is 45° ; in Kodok, Soudan, 0° ; and in Helwan, Egypt, it is 41°.

This " dip " is usually counteracted in the case of a trough compass or a magnetic compass by a movable slide or weight.

THE LIQUID PRISMATIC COMPASS

Familiarly known as the " oil Compass," this is replacing the dry type Mark VIII and is now frequently met with in the Service. Its chief advantage is that the card is immersed in a " damping " liquid so that it comes to rest quickly. The check spring and stop are not necessary and are not included. There is considerable saving of time.

Other differences from the dry type are that the outer graduations are engraved on a transparent part of the card. Immediately below the prism on the bottom of the case is a luminous patch which illuminates the graduations at night. The " lubber line " is marked on the luminous patch near the hinge. The compass is thus much more convenient for work at night.

The liquid compass is used just as is the dry type except for the differences brought about by the improvements.

All materials for sketching can be obtained from Gale & Polden Ltd., Wellington Works, Aldershot. Prices on application.

EXERCISE VIII.—BEARINGS

A.—On Plate D.

(Magnetic North is 13° west of Grid North.)

1. From Pt. 360 give the grid and magnetic bearings of Pts. 365 and 420.

2. What are the compass bearings from Pt. 420 of the road junctions in 5207 and 5903 ?

3. From the road junction in 5201 what are the compass bearings of Longton Church and Brown's Farm ?

4. What are the grid bearings of the churches at Deep, Longton and Hood when taken from the road junction in 5903 ? Give these also as compass bearings.

5. A patrol has to proceed at night from a post at 560050 to the road at 570060 ; follow the road to 597039, then return across country to its starting point. What compass bearings will be necessary for the outward and homeward journeys ?

6. If a party proceeded from Pt. 420 on a magnetic bearing of N.W. for 1,000 yards and then proceeded for 2,000 yards magnetic S.S.W., what was the grid bearing back to starting point ?

7. An aeroplane passed over the road junctions in 5207, 5004, 5201, and 5803, taking a direct course between each. On what three compass bearings did it steer ?

8. When flying over the station in 5800, a pilot has to steer for Brown's Farm and then the church at Horden. What compass bearings should be taken ?

9. In question 4, if the compass readings had been 42°, 240° and 277°, what was the I.C.E.?

10. If the compass to be used by the patrol in question 5 has an I.C.E. of 2° E., what bearings would be set on the compass ?

B.—On Plate A.

(Mag. variation for this map 11° West of Grid north.)

11. An observer at Worplesdon Church takes the compass bearings of the following points :—(*a*) road junction near Fairland's Farm ; (*b*) bridge over the railway in 5273 ; (*c*) road junction at 417724. What should the readings be ?

12. From Trig. point 205 (3971), find the compass bearings of (*a*) Western edge of Wildfield copse (3969) ; (*b*) Worplesdon Church Tower ; (*c*) road junction at 386748.

13. What are the grid and compass bearings from 448659 of Shalford Church and the level crossing at 453665 ?

14. From 451716 what are the compass bearings of : (*a*) cross-roads in 440726 ; (*b*) church tower in 437701 ?

15. From Trig. point 395 in 4565, what are the compass bearings of (*a*) Spot Height 405 in 4467 ; (*b*) wind-pump at 449646 ?

16. A patrol has to move by night from road junction 466727 to the nearest point in the woods to the East, thence through the woods and from its most northerly point to spot Height 125 (469731). On what compass bearings would it travel ?

17. A battalion holds the line of road running northwards from 388707. A patrol has to move by night from 388707 to search the copse S.W. of Littlefield Farm, returning from the north side of the copse to 391721. What compass bearings should be used ?

18. From a battery position at 404665 what are the compass bearings of the railway stations at Bramley and Shalford ?

19. Guns in position at 460720 are ranging on the road junctions at 441735, 432728 and 437705. What are the compass bearings to these points ?

20. An aeroplane passed over Worplesdon Station 4274 to the railway stations in 4469, 4466, and 4164, taking a direct course between each. What were the three compass bearings ?

CHAPTER X

SETTING A MAP

A MAP is said to be " set " when it is laid out in such a position that it can be most easily read in relation to the ground it represents. In such a position the north point points to the north, etc. Generally a map can be approximately set when the observer's position is easily recognizable, or when one or more prominent objects can be identified. If these conditions do not exist, then the map must be approximately set by the compass or by the sun. It can only be said to be *accurately* set when the observer's position has been identified with exactitude and is in true alignment with other objects represented on the map.

A map may be set with a compass or without one.

1. SETTING WITH A COMPASS.

Open the compass and lay the hair line along the magnetic north line of the map, allowing for any compass error and the annual increase or decrease of the magnetic variation. The lid of the compass should be towards north. Then turn the map and compass round until the compass needle, when steady, points along the hair line. The map will then be set.

If there is no magnetic north line drawn on the map, it can be obtained by drawing a line making an angle (east or west) with the grid north line equal to variation of the compass (E. or W.) (in England, approx. 12° W.).

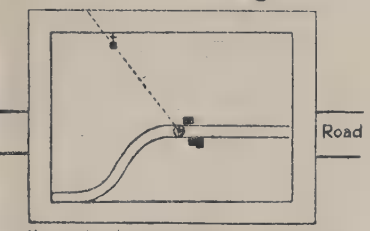
2. Setting without a Compass.

Two points or features must be recognized on the map and ground.

(*a*) *Your own approximate position and another point.* Place your ruler so that the edge runs along a line joining the two points and then pivot the map and ruler on your position, twisting until the ruler is directed at the distant point. The map is then set.

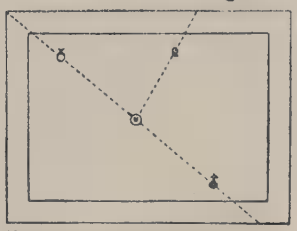
(*b*) *Two other points* (neither being your own position). You must place yourself on the straight line joining the points, if necessary getting between them; then place your ruler on a line joining them on your map, and pivot both map and ruler until the two points on the map and the two on the ground are all four in the same straight line. The map is then set.

Fig. 38.



Map set by alignment along a road

Fig. 39.

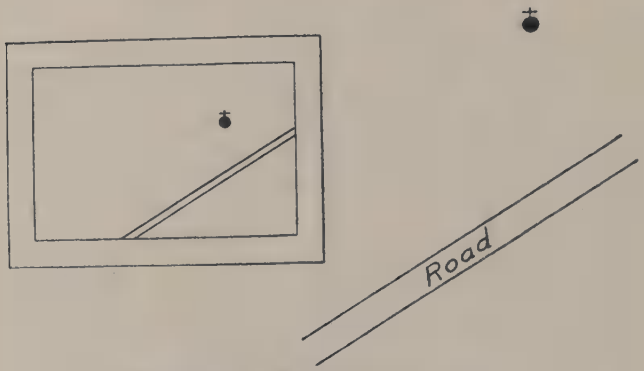


Map set by two objects in Line

Position found in each case by third object

(*c*) Your own position not known but near some well-defined straight feature such as a length of road or railway. Twist the map until the straight feature on the map is parallel to that feature on the ground. It should be checked by locating a prominent object on the ground to one side of the feature and ensuring that it is on the same side on the map, otherwise the map may be upside down. Fig. 40 illustrates this method.

FIG. 40.



Observer's Position unknown.

Setting a map requires practice. There is always some best method of doing so most suitable to existing conditions. The student should accustom himself to setting a map quickly and well under various conditions by careful application and frequent practice, on the ground, with maps of different scale.

FINDING ONE'S POSITION ON A MAP

The next step after setting a map is to find one's true position. This may be required approximately or accurately.

Accurately in order to report one's true position, or to put in detail not yet shown on the map.

Approximately, if it is merely a question of deciding in which direction to move in order to reach some given place or feature not yet visible on the ground. In this last case, when the position has been determined approximately, the general direction required may be found by resting the edge of a protractor, or of a note-book, along the line joining the observer's position

and the required point; the eye can look along this line to pick up prominent features that will give a line across country.

The method of finding one's position on the map is usually known as "re-section."

Two such methods have been illustrated in Figs. 38 and 39, where objects can be found which give a line through the observer's position. The following examples show how position may be found under other conditions.

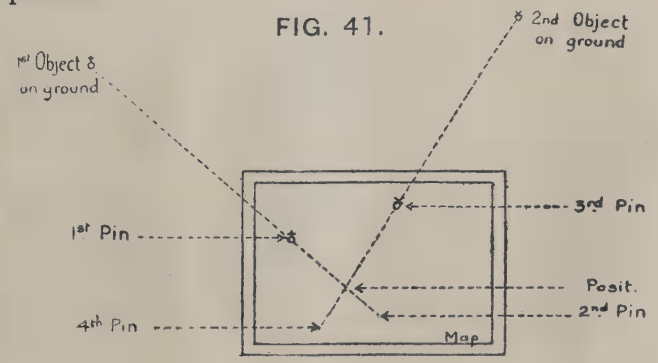
It should be borne in mind that when position has been found, accuracy should at once be checked for by alignment on a third or fourth point or feature.

RE-SECTION

1. Without a Compass.

Set the map. Identify two points on the map and ground. Stick a pin into one of these objects on the map, and then stick a pin anywhere on the map in line with the first pin and the actual object (*i.e.*, use the pins as sights). Join the pinholes by a pencil line. Repeat this process for the second object. The point of intersection of the two lines will be the required position.

FIG. 41.

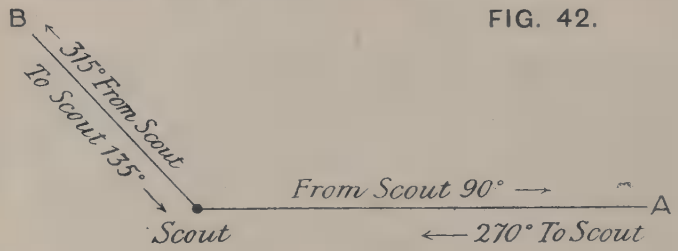


2. With a Compass.

Two points must be recognized on the map and ground, and the bearings of these must be taken and converted to grid bearings. Then, on the map, the reverse or back bearings from these points must be plotted, and the point of intersection of the lines will be the required position.

Now, it is evident that if a scout observes the bearing of a point *A* to be due east (90°), then the bearing of the scout as observed from *A* would be due west (270°); and if the same scout found a place *B* to have a bearing N.W. (315°), then the position of the scout as seen from *B* would be due S.E. (135°). Fig. 42 illustrates how the position of the scout would be plotted on the map.

FIG. 42.



The bearings from *A* and *B* *back* to the scout are called reverse bearings, or back bearings, and each gives a reading on the rim of the compass card immediately opposite to the forward bearing; therefore there is a difference of 180° between the readings of forward and reverse bearings.

The rule, then, for obtaining reverse bearings may be stated thus: If the forward bearing is under 180° add on 180°; and if it is over 180°, then subtract 180°.

For a forward bearing of 30°, the reverse bearing is 210°

,,	,,	,,	128°	,,	,,	,,	308°
,,	,,	,,	217°	,,	,,	,,	37°
,,	,,	,,	340°	,,	,,	,,	160°

EXERCISE IX

A.—On Plate D.

(Magnetic Variation 13° W.)

1. A man found that the road junction 583032 had a compass bearing 127° and that Barham Church was 351°. What was his position ?

2. What was the position of a scout who found that Barham Church was on a magnetic bearing of 150° and that the N.W. corner of the enclosure at the Shooting Box was 101° ?

3. How should a man who was halted at the road junction in 5803 set his map without a compass ?

4. A man was proceeding along the road eastwards from Hood. At what point did he find that Longton Church was due south of him ?

5. At what point did a man find that Longton Church was on a magnetic bearing of 123° while Hood Church bore 3° ?

6. A scout found that Horden Church was on a compass bearing of 303°, while Brown's Farm was 225°. Where was he ?

7. When Hood Church was on a compass bearing of 75° from him, a man found that the Forge bore 343°. What was his position ?

8. A person who was at a point grid north of the Abbey found that the Forge was due east of him. State his position on the map ?

9. What was the position of a man who found that Nelson House was on a magnetic bearing of 51°, and that the cross-roads in 5809 bore 349° ?

10. When proceeding on a compass bearing of 22° from the Forge, a scout found that Barham Church was magnetic 107° from him. What was his position ?

B.—On Plate A.

(Magnetic variation 11° W.)

11. A scout was at the bridge at 429727. How could he set the map without a compass ?

12. A man moving along the road south-eastwards from Fairland's Farm (4072) found that the compass bearing of Worplesdon Church was 37°. What was his position on the map ?

13. At 424694, how should the map be set without a compass ?

14. From what position was it found that the compass bearing of the church at 444732 was 76°, and the S.W. corner of the enclosure at Cox's Farm (4373) was 341° ?

15. From an O.P. in square 4668, the magnetic bearing of the end of the cutting at 452704 is 335°, and that of Merrow Church (4670) is 17°. Give the map reference of the O.P.

16. When Worplesdon Church was at a compass bearing of 280° from him, a man was at a point near the railway line. State the map reference of his position.

17. What was the position of a post from which the pond at 407715 bore magnetic 72°, and Compton's Farm (3871) was 310° ?

18. Without a compass, how should a man set his map on arriving at the bridge near Bower's Mill (4572) ?

19. A man was proceeding northwards along the main road from Road Junction 436738. What was his position when he found that the compass bearing of Worplesdon Station was 295° ?

20. From what point does the S.W. corner of the wood at 424666 bear magnetic 333° and Shalford Church (439666) magnetic 68° ?

CHAPTER XI

ENLARGEMENTS AND FIELD SKETCHING

THE preparation of a map is the work of skilled men, but it is often necessary to produce a large-scale map in order to show some particular information, such as the dispositions of a battalion or a company, or perhaps details of a billeting scheme.

This large-scale map may be either an eye sketch on the ground, or a compass sketch (which is described in Chapter XII on Traversing), or an enlargement of a portion of a small-scale map, or more usually by a combination of these. Whichever is adopted, the sketcher should always bear in mind that the purpose of the large-scale map or sketch is to convey information to a third person who probably has never seen the ground. He should therefore continually consider whether he is illustrating that information in a manner which that other person can readily understand.

Enlargements.—It must be realized that an enlargement conveys nothing more than the original small-scale map from which it was made. It is only of use *after* the sketcher has been out on the ground and filled in the extra detail required.

Usually the original map is gridded and the grid square or squares containing the area to be enlarged should be sub-divided into smaller squares. On the 1-inch map a suitable sub-division is four small squares to one grid square. The diagonals of these small squares should then be drawn. If the map is not gridded, squares of a suitable size (sides—half inch) should be drawn to cover the area to be enlarged.

The sketch sheet should then be prepared by copying the squares at the new scale and drawing their diagonals. The detail can then be copied on the enlargement, square by square, in corresponding positions by eye. If greater accuracy is required, the exact points where detail crosses the sides of squares or diagonals can be fixed by measurement with the scale of the original map and plotted on the enlargement.

This is known as the Union Jack method and is illustrated in Fig. 43.

Suppose it is required to enlarge the area in one grid square of the 1-inch map to a scale of 4 inches to a mile. The sides of the square in the enlargement would have to be four times as long as those of one grid square. In fact the square can be pricked through on to the sketch sheet from the 1-inch map, the area being equal to 16 grid squares.

This method is simple enough when the new scale is a multiple of the original, but it is not so easy when enlarging to a scale which is not a multiple, particularly if the original map is in the unfamiliar units of a foreign country.

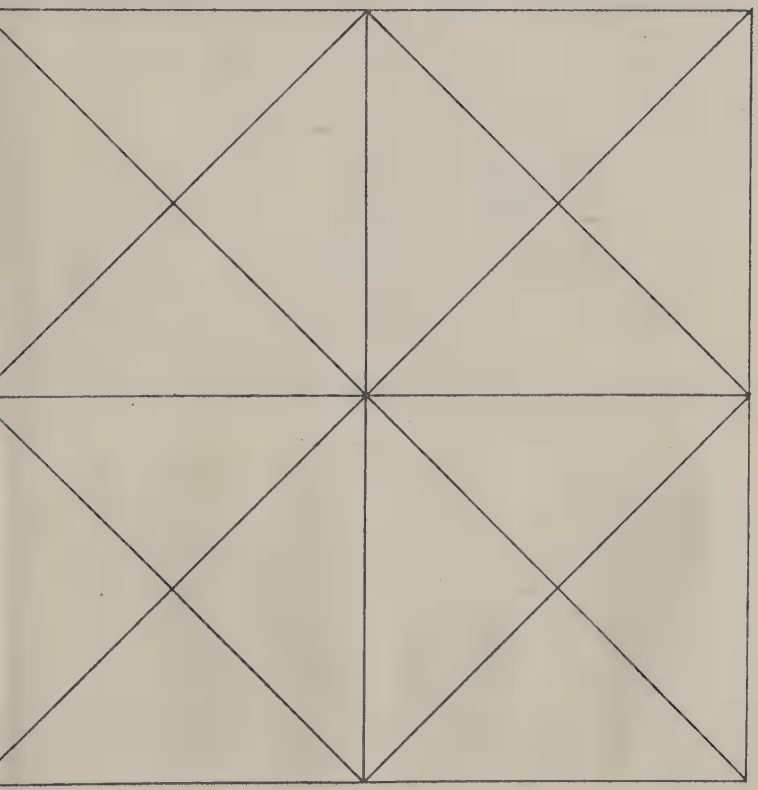
In such cases the method is to construct a scale of yards (if it does not possess one already) for the original map. This can be done from the R.F. Then construct another at the required scale for the enlargement. The sides of the squares on the original map can now be measured in yards and the squares reproduced at the scale of the enlargement.

If the area required to be enlarged is not exactly a square or rectangle, the figure enclosing the area may be reduced to two triangles by drawing one diagonal, the sides of these triangles measured in yards, and the triangles reproduced at the enlarged scale.



FIG. 43

Showing method of enlarging by "Union Jack" method from 1" scale to 4" scale.



If desired, the relative lengths of the sides of the squares may be calculated. If ½-inch squares be placed on $\frac{1}{40000}$ map, then the squares on the 6-inch ($\frac{1}{10560}$) enlargement will be :—

$\frac{\frac{1}{10560}}{\frac{1}{40000}}$ of ½-inch = 1·89 ins. (1·9 ins. approx.).

It must be remembered that on an enlargement it will not be necessary to make conventional signs any larger than on the original ; houses, etc., will also be indicated by signs which are about the same size as those shown in the map ; the reason for this is that in the first case it was necessary for the sake of clearness to make the sign of a larger size than the scale warranted.

When all the detail on the map has been sketched on the enlargement it should be taken on to the ground and the extra detail filled in from observation, bearing in mind the purpose for which the sketch is required.

The shape of the ground can be shown if necessary, by drawing form lines at a suitable V.I. between the contours enlarged from the original map.

Copying or Reducing.—It is obvious that both these may be done by using principles similar to those just described, though the quickest method of copying is by making a tracing.

Field Sketching.—This type of map is drawn when speed is more essential than accuracy ; for instance, to show the dispositions of a platoon locality, or to illustrate a reconnaissance report. The scale will normally be one or two hundred yards to an inch.

If time permits, the main points in the area will be fixed by prismatic compass bearings and pacing, as described in Chapter XII, and plotted on the sketch sheet, which will usually consist of a sheet of Army Book 153. The detail will then be sketched in by eye in the same way as in an enlargement on the ground.

If, however, there is no time to fix a framework by pacing and compass bearings, the whole of the sketch must be drawn by eye from one or two points from which the whole area can be seen. Distances and bearings must be estimated, and the shape of the ground shown by form lines.

Form Lines.—It will frequently happen that the whole of a sketch will consist of form lines, there being no roads or hedges in the area, and considerable practice is required before the beginner can draw these in with confidence. The choice of V.I. depends on the steepness of the slopes, and, generally speaking, the steeper the slopes the larger the V.I. It will seldom be less than 10 feet. As few form lines as possible should be put in to avoid obscuring other important detail.

The difference in height between the highest and lowest points in the area must be estimated by comparison with houses or trees. Then the general directions of the water-sheds of the spurs and the watercourses of the valleys should be sketched in lightly. On this framework the form lines can be drawn, remembering that they will be close together where slopes are steep and vice versa. The height of the lowest form line can be chosen at any convenient figure and the others must be numbered in relation to this one.

Finishing off Sketches.—Relevance and accuracy of detail are more important than artistic effect. Every sketch must have on it a heading describing the area by means of map references and the purpose for which it has been drawn. On the right-hand side the North Points should be inserted. At the bottom a scale of yards should be drawn and the V.I. should be written in under the scale. It should be signed in the bottom right-hand corner and the sketcher's

rank and appointment added. The time and date when it was completed should be inserted in the left-hand bottom corner and a note added as to the state of the weather.

If the sketch is a tactical one, the direction of the enemy should be towards the top of the sheet, otherwise the sketch should be drawn so that north is at the top of the sheet.

Plates B and C must be carefully studied and the conventional signs illustrated therein must be used on all military sketches.

EXERCISE X

NOTE.—In enlargements, the field sketching conventional signs must be used. (See Plates B and C.)

1. A map drawn at $\frac{1}{21120}$ is to be copied at $\frac{1}{12672}$. If the original is ruled with one-inch squares, find the length of the side of the squares of the copy.

2. An enlargement of portion of $\frac{1}{25000}$ map is required at a scale of $\frac{1}{10560}$. Prepare a sketch sheet for an area of four grid squares.

The following questions are set on Plate A :—

3. Reproduce at a scale of 3 in. to a mile the squares 4272 and 4372.

4. For purposes of a company scheme enlarge square 4069 to a scale of $\frac{1}{15840}$.

5. Your company is to be billeted in some part of square 4173. Make an enlargement of this square at 6-inch to a mile, so that you can copy in the necessary detail from the battalion plan.

6. A battalion is to carry out a scheme in squares 4068 and 4069. Prepare an enlargement of these squares, at a scale of 400 yards to 1 inch.

7. A patrol has to move along the main road from the cross-roads at Pile Hill (4374) to Bellfields (4370). Prepare at a scale of $\frac{1}{31680}$ an enlargement of the line of march showing detail up to about half a mile on either side of the road.

8. A company defence scheme is to be carried out in 4372. Prepare an enlargement of this square at a scale of 200 yards to 1 inch.

9. Prepare at a scale of $\frac{1}{10800}$ a sketch map of the area in 4464.

10. A camp is to be pitched in the area enclosed by the following points—470696 ; 479690 ; and 470690. Prepare an enlargement of this area, including the length of road, at a scale of 200 yards to 1 inch.

CHAPTER XII

TRAVERSING OR PRISMATIC COMPASS SKETCHING

For this a compass is essential.

This means sketching by means of a continuous series of measured straight lines, of which you take the direction or bearing with a compass at each change of direction as you proceed. These lines are called *Traverse* lines or legs, and the sketcher must measure actually along these lines. The detail is sketched by means of *offsets* or cross-bearings. Offsets are measurements drawn at right angles to the traverse lines, and should seldom be longer than 100 yds.

Distances are measured by pacing. The average man can adapt the length of his pace to a yard with a little practice over a known distance of, say, 100 yds. This is easier than counting the number of 30-inch paces and increasing the total by one fifth to give the correct number of yards.

The tendency of pacing too short uphill and too long downhill must be avoided.

Cross-bearings are bearings taken from the traverse line to fix by intersection the position of any required point which is beyond the limits of an offset.

Traversing can be carried out in two ways :—

(1) By recording all observations in a field book and plotting them at leisure.

(2) By plotting the observations and filling in the detail as you proceed with the sketch.

Traversing is useful in forests or where the grass is very high and so the view is limited, making it impossible to obtain the intersections of " bearings " taken to distant objects.

TRAVERSING WITH THE FIELD BOOK

The field book contains a " sketchy " record of the route followed together with essential observations.

The first two columns are ruled narrow to contain figures. Column 1 shows the number of the *station* (or point from which the count is made), and also the forward bearing from this point, taken with the prismatic compass. Column 2 sets out the distances in yards traversed in a forward direction to each point at which a halt is made; the figures are entered opposite the entry of detail in columns 3 and 4 to which they refer.

The line between columns 3 and 4 is intended to indicate the observer's path and as he goes forward the detail on either side is noted.

Column 5 should contain a record of the heights of any important points.

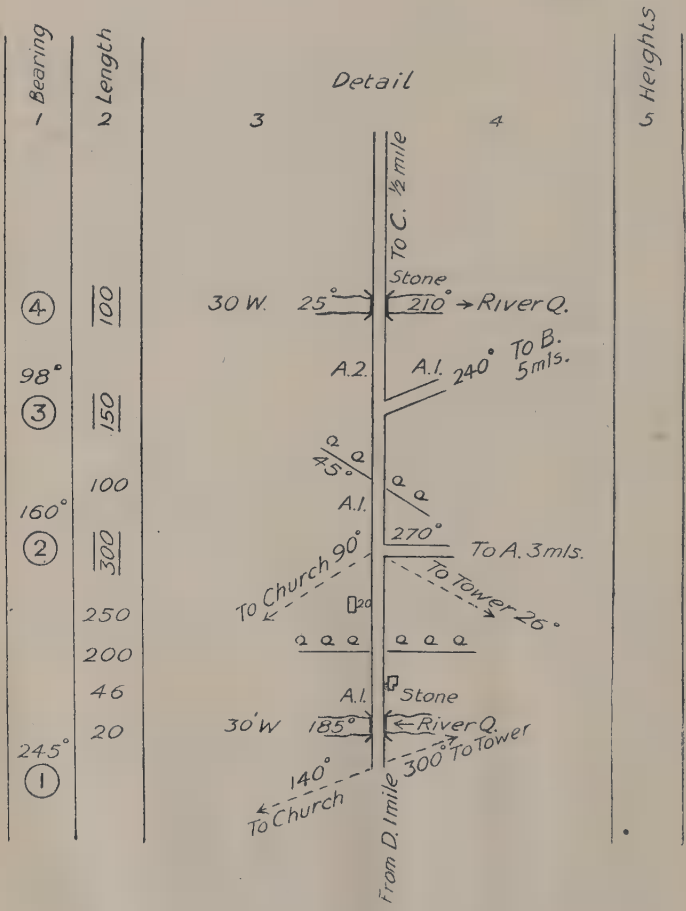
Figure 44 gives an example of the field book entries made in a simple traverse.

The sketcher starts at (1) and takes a bearing along the road as far as he can see—in this case the bearing is 245°. The necessary entries are made in column 1, at the bottom of the page; it should be noted that all entries are made from the bottom to the top.

He observes to his left a church at a bearing of 140°, and notes the fact in column 3, while a bearing of 300° to a tower on his right-hand side is noted in column 4.

As he goes forward counting the paces, the general idea of the road is entered along the line between columns 3 and 4. When he has gone 20 yds. forward he arrives at a bridge—the figure 20 is marked in column 2 and the details of the bridge are entered on the traverse line. The direction of the flow is noted, together with the bearing and the width of the stream; the material of which the bridge is made should be noted, and any other points such as its capability, or otherwise, of supporting heavy vehicles.

FIG. 44.


1 Bearing
2 Length
Detail
3
4
5 Heights
To C. ½ mile
Stone
30 W.
25°
210°
River Q.
A.2.
A.1.
240°
To B. 5 mls.
98°
45°
160°
A.1.
270°
To A. 3 mls.
To Church 90°
To Tower 26°
A.1.
Stone
30'W
185°
River Q.
300°
To Tower
140°
To Church
From D. 1 mile
24.5°
100
150
100
300
250
200
46
20

Taking up the count from 20 *yds.* at the point where he entered the bridge, he paces forward until, at a total of 46 yds., he reaches a house on his right-hand side. He notes this and also the fact that the road is classed as A1.

When the total is 200 yds., hedges meet the road at right angles on both sides, and these facts are noted.

Still proceeding on the traverse line (and taking up the count from 200 yds.) he ultimately arrives at a house on his left-hand side when the total is 250 yds.

Later, with the total at 300 yds., he reaches the end of the first leg of the traverse, and this fact is recorded by writing the figures for this entry between two lines and at right angles to the other figures in column 2. As this point is also the start of the second leg, the entry (2) is also made in column 1, together with the bearing 160°, along the new leg.

Before starting, a note is made of the bearings from this point of the church and the tower already noticed at station (1), so that their positions may be plotted. Another entry indicates the direction of the road from *A* which meets the other at this halting point.

Along the second leg of the traverse the sketcher notes that the road is of the A1 class; at 100 yds. hedges meet the road on either side at angles of 45°; at 150 yds. he reaches the end of the second leg, and enters the number in the appropriate way. At this point a road (A1) to *B* is at a bearing of 240°.

The point at which he is standing is the beginning of the third leg, and the bearing of the new traverse line is 98°; these facts are noted in column 1. Moving along the road, a note is made that it is class A2, and after 100 yds. the line ends at a bridge; and as the traverse finishes at this point it is entered as station (4). The necessary details of the bridge and the stream are shown in columns 3 and 4.

PLOTTING THE TRAVERSE

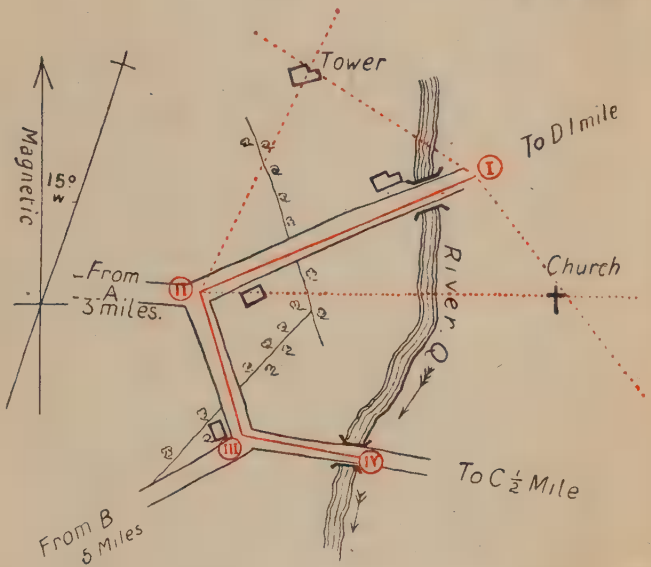
When the sketcher gets home he must transfer his observations, which, of course, are not drawn to scale, and which might be termed pictorial memoranda, to paper, and so form a proper sketch. To do this he first covers a clean piece of sketching paper with magnetic meridians (or magnetic north and south lines), which may be drawn in any direction so long as all are parallel. From any point on these lines he will be able to plot off his bearings and so get the sketch transferred to paper. If the sketch is a fairly long and narrow one, he draws, let us say, his magnetic lines straight up and down the paper with the top end marked N.

The reader may at first be puzzled about these magnetic meridians, as to the direction in which they are to be drawn; let him remember that they may be drawn in *any* direction, so long as they are all parallel, but as a rule a sketcher gets into his head, as he proceeds, a rough idea of the shape of the whole piece of ground he is sketching and its direction with regard to the north, and so he places his magnetic meridians and marks one end of them north in such a manner that will enable him *to get the whole of his sketch on to his paper.*

Fig. 45 shows the observations recorded on Fig. 44 plotted. The magnetic meridians have been purposely omitted, as in a field sketch they would only be put in in pencil and rubbed out after the sketch was inked in, because their only purpose is to serve to plot off bearings (or angles with reference to the magnetic north). Traverse lines in red, other bearings in dotted red lines, are also put in, for instructional purposes only. Normally they would be omitted.

The necessity for ruling meridians disappears if squared paper with faint ruling be used for the work.

FIG. 45



Scale $\frac{1}{7200}$ or 200 Yards to 1 inch



EXERCISES

No. 1.—The following entries in a field book are to be neatly plotted at 24 inches to a mile.

1 Bearing	2 Length
③	103
334° ②	225
	105
	43
277° ①	20
⑤	280
330° ④	290
28° ③	110
12° ②	345
	250
	148
	100
40° ①	

FIG. 46.

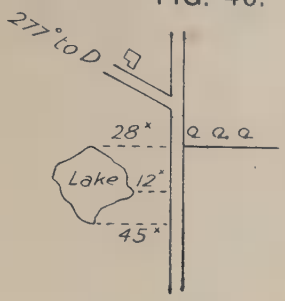
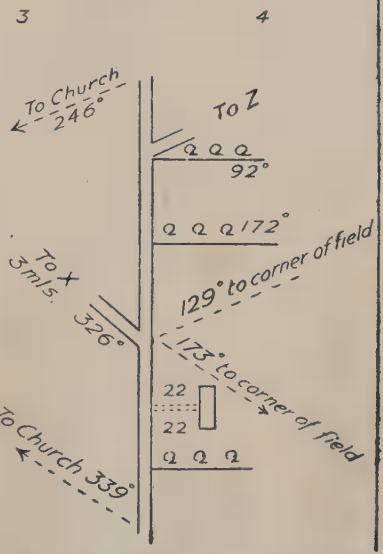


FIG. 47.

Detail

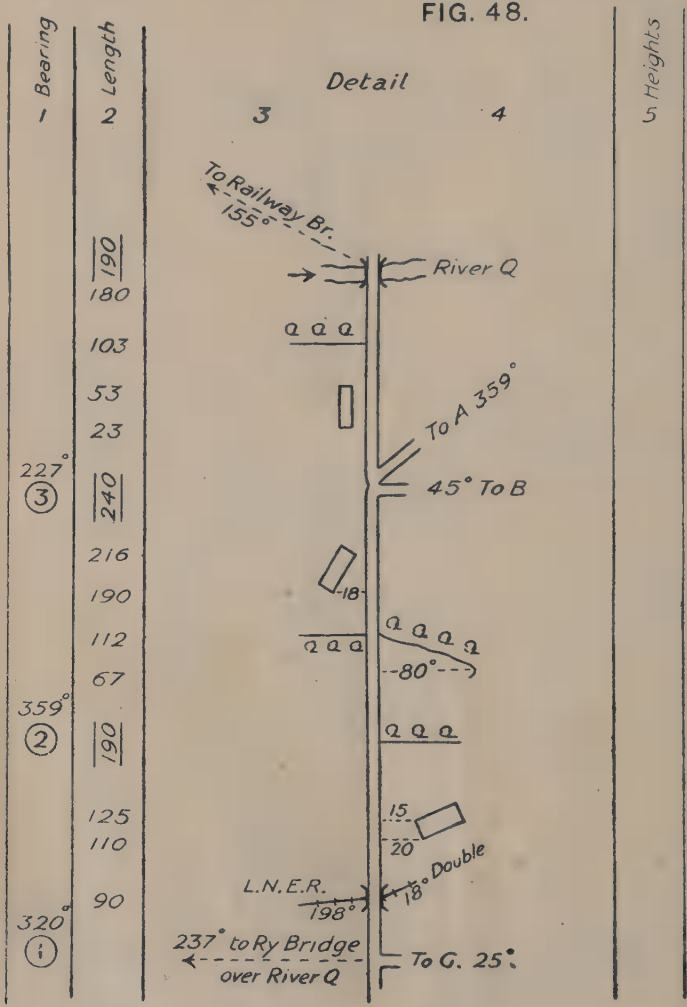


5 Heights

No. 2.—The entries in Fig. 47 have to be plotted at scale of 6 inches to a mile.

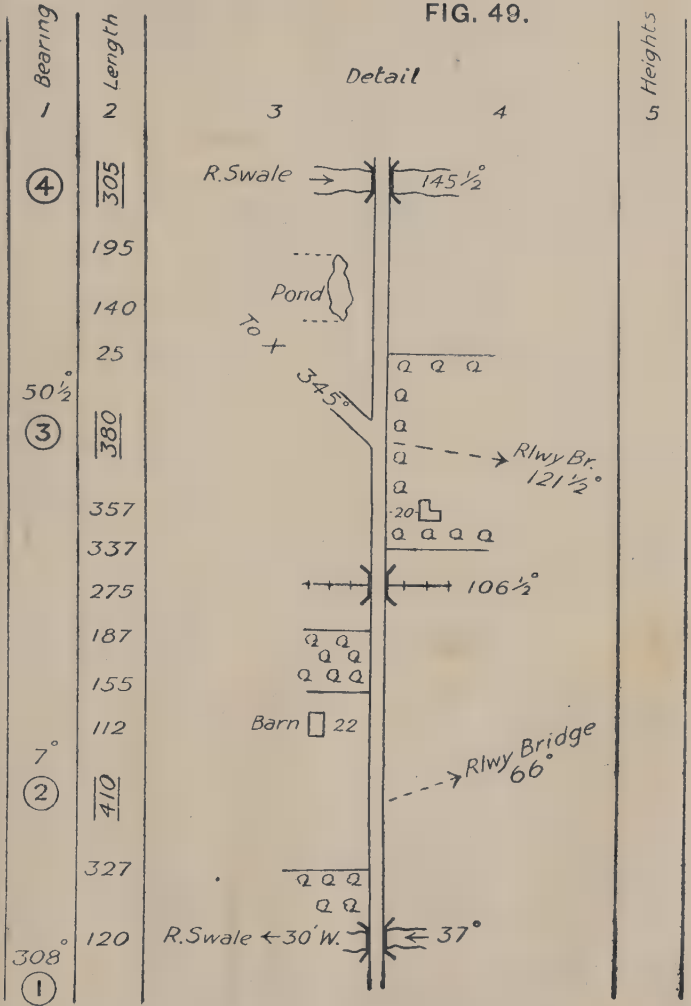
No. 3.—Plot at a scale of 12 inches to a mile the entries given in Fig. 48.

FIG. 48.



No. 4.—Plot at a scale of 12 inches to a mile the entries given in Fig. 49.

FIG. 49.



CHAPTER XIII

TO FIND DIRECTION OF TRUE NORTH

The direction of the True North may be found—

1. By means of the Sun.
2. By means of the Pole Star.
3. By means of a good map of the country.

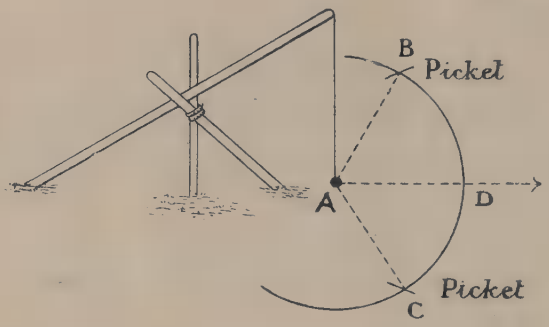
(1) By the Sun.

(*a*) *At noon* (1 o'clock Summer Time) the sun is due south, and a pencil or stick in an upright position will cast a shadow that forms an *approximate* N. and S. line.

(*b*) To determine more accurately the direction of the north, two sticks should be lashed together and used to support a pole pointing northwards. From the tip of the pole drop a plumb line to the ground, as at *A* in Fig. 54, and with this point *A* as centre, and at any convenient length as radius, describe an arc of a circle. Some time before noon (1 o'clock Summer Time), watch the shadow of the pole as it gets shorter, until the tip of the shadow just touches the circumference of the circle ; mark this point with a picket, as at *B*. The shadow will gradually become shorter, and will then begin to lengthen again. When its end again touches the circumference, mark the spot with another picket, *C*. Bisect the arc *BC* at *D*. The line *AD* will mark the direction of the true north, and by taking the bearing of this line the variation of the compass may be ascertained.

A level surface of ground should be carefully prepared for this method.

FIG. 54.



A simpler application of the same method can be practised on a plane table or other small surface on which a sheet of drawing paper has been fixed.

A circle having been drawn on the paper, an upright pencil secured with sealing wax to the centre of a coin or fixed upright in an ordinary cotton-reel, is placed over the centre of the circle.

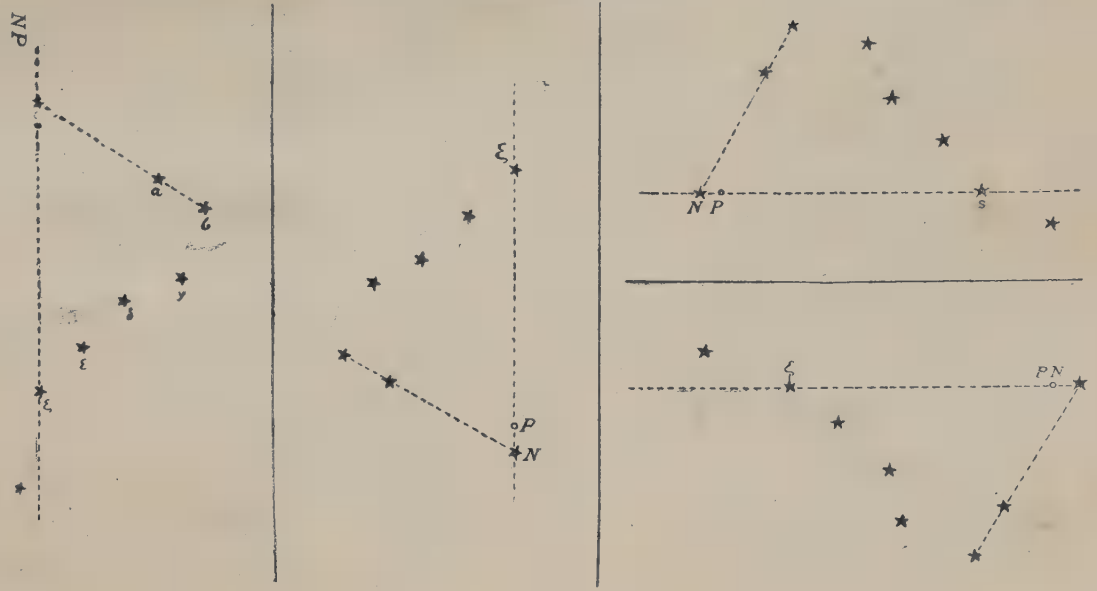
The pencil now takes the place of the plumb line in Fig. 54, and the method of finding true north is the same as already explained.

(*c*) *A very rough approximation* to the direction of true north may be obtained by means of a watch.

Point the hour hand of the watch to the sun. (*A* pin held upright against the edge of the hour hand so that the shadow from the pin falls along the hour hand will ensure accuracy.) Then bisect the angle formed by the hour hand and a line joining the centre of the dial to the Figure XII, or 12 o'clock. *This line will point due south.*

When Summer Time is in operation put the hand back one hour; two hours if Double Summer Time.

Star Diagrams. FIG. 55.



(2) By the Pole Star.

All the stars seen in our sky seem to revolve once in every twenty-four hours round a point called the North Pole. The nearest star to this point is called the Pole Star, and it is at an angular distance of about 1° from that point. The Pole Star may be found by means of the brilliant constellation known as the Great Bear or Plough. The two stars at the head of the Plough (marked *a* and *b* in Fig. 55) are called the "pointers," and if the line from *b* to *a* be produced about five times its own length, the Pole Star will be found at the end of this line.

Note.—The line must always be drawn from *b* to *a*, whatever position the constellation may occupy.

A line from an observer towards the Pole Star will always be correct to within about 1°, and this direction may simply be marked by placing a lantern some distance in front, in the direction of the Pole Star, and then by means of a plumb line to align the position of the observer with the lantern and the Pole Star.

This direction may also be fixed by hanging a plumb line from the top of a window which points north, and then placing a pin upright on a table, in line with the string and the star.

To obtain the true north with *greater accuracy*, we are helped by the fact that the star Zeta of the Great Bear, the North Pole, and the Pole Star, are in a straight line, and so if we make the observation when Zeta is either vertically above or below the Pole Star (*i.e.*, when the plumb line covers both Zeta and the Pole Star, and those points are hence in the same vertical plane as the North Pole), then the line obtained will be *true* north.

(3) By a Map.

If a map be *set* as in Chapter X, then the true north line of the map will point to the true north.

POSITION OF THE SUN.—Fig. 32 shows approximately the position of the sun at various seasons. It may be briefly noted :—

(*a*) The sun rises due east and sets due west only at the equinoxes (March 21st and September 21st).

(*b*) When the sun rises at Midsummer (June 21st) its bearing is $51\frac{1}{2}°$, and at setting $308\frac{1}{2}°$.

(*c*) At Midwinter (December 21st) the bearing is $128\frac{1}{2}°$ when it rises, and $231\frac{1}{2}°$ when it sets.

This applies approximately only to places in the northern hemisphere of the latitude of the British Isles (50°–55°).

In places in the southern hemisphere of the same latitude (*b*) and (*c*) are reversed.

NOTE ON THE HORIZONTAL CLOCK CODE

This code is used when map references cannot be given, to indicate to an observer the position of any target, by reference to a point previously agreed upon.

For this purpose the *reference point* is considered as being the centre of a horizontal clock face placed on the ground, as in Fig. 56, the XII of the clock pointing north.

The direction of the target can be indicated by a *clock ray* from the reference point, and the distance in yards must be given; thus "Manœuvre Map—Salisbury Plain Area—Can see enemy gun firing—One o'clock, 700 yards from Factory Chimney—Time 13.45."

If the direction and distance have been accurately judged, it will be possible for artillery to get on to the target. The reference must always be to some place easily recognizable. The setting of the clock face is most readily done if the observer knows the bearing of the reference point; this gives the bearing of the ray at the point of the clock face remote from the observer; in the example in Fig. 56, the observer's line of sight is on a bearing of 300°. Thus, reckoning 30° for every "hour" on the clock, the side remote from the observer is ten o'clock, and a ray towards him is four o'clock. The clock is thus fairly easily set.

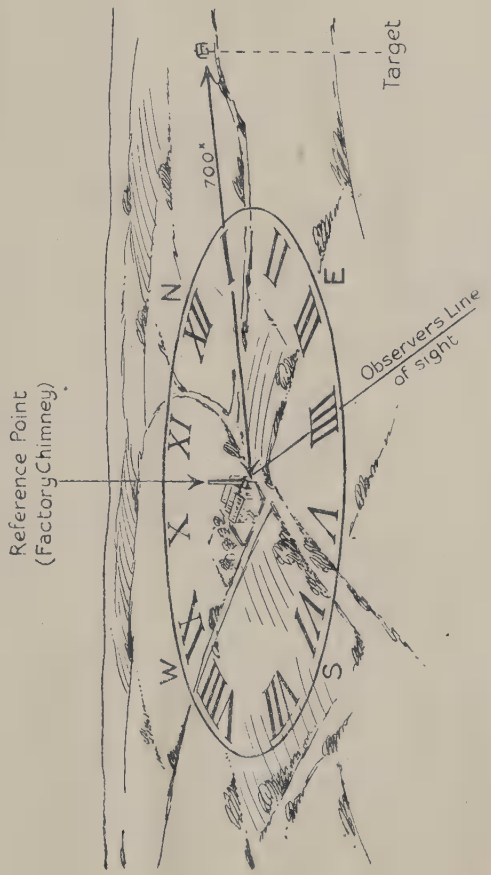

Target
700'
N
E
W
S
Observers Line of sight
Reference Point (Factory Chimney)

FIG. 56.

MAP READING TESTS

Test A.—On Plate D.

(Scale 1 inch to 1 mile. V.I., 50 ft. Magnetic Variation, 13° W. of Grid North.)

A battalion is moving along the road to HORDEN, and its head passes the road junction in 5201 at 9.30 a.m.

1. If the average rate of travelling is $2\frac{1}{2}$ miles per hour, at what time will it reach HORDEN (4910)?

2. At what part of the road does it traverse the steepest gradient? Express this gradient as a fraction.

3. When the leading company is on the road in 4905 will it be visible to an observer at the road junction in 5201?

4. On reaching the road junction in 5007 it became necessary for a platoon commander to set his map without a compass. There was no sun visible; how could the map best be set?

5. An observer found that from his position the Church at BARHAM was on a compass bearing of 92° while the Church at HORDEN was 1°. State the observer's position.

6. A person on the road at 506070 noticed that an aeroplane over Pt. 365 was at an angle of elevation of 4°. What was the height of the machine above ground?

7. Show in square 5006 the 2nd Blankshire Regiment in column of route northwards along the road, while at an interval behind them follows the 9th Infantry Brigade Headquarters and the remaining two battalions of the Brigade. On the road in square 5004 show in column of route the 20th Field Regiment R.A. (Mechanized) and the 9th Infantry Brigade M. Transport. Mark also the 6th Tank Battalion halted about 510040.

Test B.—On Plate D.

The leading battalion of another brigade is advancing along the road running northwards through HOOD to BARHAM.

1. If when the vanguard reaches the cross roads at HOOD the brigade occupies road space stretching back to 560997, in what time will the end of the column reach the cross roads ? (Average rate, $2\frac{1}{2}$ miles per hour.)

2. The brigade headquarters are to be placed at the School at HOOD.

(*a*) Give the map reference of this point.

(*b*) State whether the road to the neighbouring brigade headquarters at Brown's Farm is sheltered from observation from northwards, or not.

3. A battery position is marked out at 560030. What compass readings and what ranges should be registered for the Shooting Box, cross roads, at NELSON and the road junction at DEEP ?

4. If the cross roads at HOOD are at a level of 345 ft. what is the gradient on the road between that point and Pt. 550026 ?

5. (*a*) What is the height of the ring contour shown on the map north of LONGTON ?

(*b*) Within a radius of four kilometres from 550040 give an example of (i) A knoll ; (ii) A col or saddle ; (iii) A salient ; and (iv) A re-entrant.

6. An aeroplane 100 ft. above Pt. 420 comes to the ground at 560074. What was the gradient of its descent ?

7. Indicate on the map :—

(*a*) 18th Infantry Brigade Headquarters at HOOD.

(*b*) 19th Infantry Brigade Headquarters at BROWN'S FARM.

(*c*) Artillery—8 guns in position about 560030.

(*d*) Ammunition Dump in 5600.

(*e*) Casualty Clearing Station at 550027.

(*f*) Observation Post near Pt. 360.

Test C.—On Plate D.

The divisional front occupies the high ground about Pt. 365 and Pt. 420.

1. (*a*) What is the nature of the slope between Pt. 365 and Pt. 420 ?

(*b*) What term is used to describe the land along the line joining these points ?

(*c*) What feature is indicated at the space on the map between the 350 ft. contours in 5508 ?

2. Determine what parts of the road running across the north of the divisional front are visible from Pt. 420.

3. An O.P. is situated so that from it the Church at LONGTON has a compass bearing of 199°, while the Church at BARHAM has a compass bearing of 263°. What is the map reference of the O.P. ?

4. A company commander has to occupy the Shooting Box (5409) compound as a forward position. Make an enlargement, at 3 inches to a mile, of the small square in which this is situated, in order that the necessary dispositions may be marked on it.

5. First line transport to unload at BARHAM has to proceed loaded via LONGTON and 597039, the return journey being via HOOD. If the loaded rate of travelling was 10 miles per hour, and unloaded 15 miles per hour, and there was a wait of half-an-hour at BARHAM, in what time should a loaded lorry which passed the road junction in 5600 return to that point ?

6. Make a time-scale for the lorry travelling at 10 miles per hour.

7. In the enlargement made for No. 4 show :—

(*a*) " A " Company Headquarters with two platoons (Nos. 5 and 6) at the house.

(*b*) Nos. 7 and 8 Platoons in position facing north.

(*c*) A coiled-wire entanglement placed on the north side of the enclosure.

(*d*) Visual Signalling Station on the road near 540089.

Test D.—On Plate K.

(Magnetic North is 13° West of Grid North.)

1. An armoured car at the bridge in 1790 has to proceed to the road junction at CLIFTON. How long will it take at 25 miles per hour ?

2. Make a time-scale for the car at 25 miles per hour.

3. At what point will the car first become visible to an observer at 184951 ?

4. (*a*) If the road level at 183946 is 242 ft., what is the average gradient on the road between that point and 186940 ?

(*b*) What is the nature of the slope between these points ?

5. From 190940 a man estimated that the compass bearing of the Church in 1895 was 340°.

(*a*) What was the error of his compass ?

(*b*) How could he have measured the error ?

6. At the cross roads at BRAMCOT a halt was made to set the map without a compass. How could this be done ?

7. From the area shown on the map, give examples of :—(*a*) a Col ; (*b*) Salient ; (*c*) Re-entrant ; (*d*) Water-course.

Test E.—On Plate K.

A vanguard has reached 214900 in its advance northwards along the road. Cyclists are sent forward to 212946.

1. (*a*) How long will they take at 10 miles per hour ?

(*b*) What is the steepest road gradient they will meet with ?

2. (*a*) What is the height of the ring contour N.E. of Road Junction 212946 ?

(*b*) Does it indicate shelter from observation for the party whilst a look-out is kept at 209948 ?

3. Arrangements were made for the scouts to send visual signals from about 215939. Two positions were suggested as receiving stations, 220910 and 224912. Which would serve the purpose better ?

4. At one part of the march it was found that the Church at THORPE had a compass bearing of 273° while the Church in 2292 was 174°. From what position were these bearings taken ?

5. From 170940 to 200960 show a double line of railway, keeping at a level of 250 ft. Show bridges, embankment and cutting, and also a station at 197958.

6. An aeroplane which was 100 ft. above 217939, landed at 210937. What was the gradient of its descent ?

7. Show on the map :—

(*a*) At WORTON—Headquarters, 100th Division ; 100th Divisional Artillery ; 159th Infantry Brigade Headquarters ; Radio-Telephony Station.

(*b*) At NORTON—Headquarters, 160th Infantry Brigade ; 95th Medium Regiment R.A.

(*c*) In square 2191—Divisional Petrol Dump ; Divisional Engineer Dump.

Test F.—On Plate K.

A party on the road at 233953 has to proceed via NORTON to 241900.

1. How long will it take a cyclist to complete the journey at 12 miles per hour ?

2. Make a time scale for the cyclist.

3. When the party is at 233953 (336 ft.) can it observe troops at the following points :—(*a*) 230936 ; (*b*) 243924 ?

Also, at what point on the journey south will the party first come into view of transport halted at 241900 ?

4. Make a road section of the line of march set out above. What is the steepest gradient on it ?

5. What was the position of an observer who found that the Church in 2494 was on a magnetic bearing of 354°, while that in 2492 was magnetic 233° ?

6. (*a*) What is the height of the ring contour in 2293 ?

(*b*) What does it represent ?

(*c*) What feature is indicated along the line from 212932 to 223938 ?

(*d*) And from 224935 to 226938 ?

7. Show by sketching signs on the map :—

(*a*) Heath about 182935.

(*b*) A spring at 194918.

(*c*) Dense woods about 185920.

(*d*) Marsh about 208903.

(*e*) Hops, 9 ft. high, in the angle of the road about 205936.

Test G.—On Plate K.

A force is marching from 259910 by road via WORTON to THORPE (1993).

1. At what point on the line of march will it first see :—(*a*) The houses at THORPE ; (*b*) The Church in 2494 ?

What is the nature of the slope between :—(*c*) 236917 and 223910 ; (*d*) 231924 and 222920 ?

2. In what time will a lorry travelling 15 miles per hour cover the line of march from 259910 to 192930 ?

3. From 204936 what are the magnetic bearings of :—(*a*) The Church in 1993 ; (*b*) The Inn 2194 ; (*c*) The Church in 2292 ?

4. A man at 207938 noticed an aeroplane which happened to be vertically above 246923. What was the least height of the machine above the ground ?

5. (*a*) Explain the various letters shown under the place names on the map.

(*b*) Give 8-figure map references for the Churches in 1991 and 2395.

6. To get a general idea of the view looking eastwards from 207929, a man drew sections between the following points :—(*a*) 207951 to 237924 ; (*b*) 237924 to 220900.

Draw sections along these lines. Would the sections fulfil the purpose reasonably well ?

7. Show on the map :—

(*a*) 2nd Bn. Blankshire Regiment about 211927, with Anti-Tank Artillery (2 guns).

(*b*) At Worton—116th Infantry Brigade Headquarters with two battalions ; 2 companies Mech. Transport.

(*c*) About 234925—29th Field Regiment R.A., and Visual Signalling Post.

Test H.—On Plate K.

1. Visual signalling stations are posted at 188927 and 230930.

(*a*) How many yards apart are they ?

(*b*) Is there an uninterrupted view between them ?

(*c*) Are they both sheltered from observation from the direction of Appleby ?

2. A messenger from 188927 has to proceed at night to 230930. He decides to do this via the road junction 207929.

(*a*) What compass bearings will he need for the journey ?

(*b*) State in yards the length of each part of the journey.

(*c*) How long will it take at 2½ miles per hour ?

3. If 188927 is at a height of 320 ft. and 230930 395 ft., what is the gradient of the line of sight between the points ?

4. (*a*) What is the height of the ring contour in 2293 ?

If a man walked (*b*) From 220930 to 230940 ; (*c*) Then 230940 to 230930 ; and (*d*) 230930 to 223923, what type of feature did he pass across, or along, in each case ?

5. For a V.I. of 50 ft. at the scale of this map, what H.E. corresponds to 1° of slope ? Make a scale line of this length, and add lengths corresponding to 2° and 3°.

By using the scale of slopes so constructed, find what parts of the roads within a radius of 2 kilometres from 240920 have gradients gentler than 1° or steeper than 3° of slope.

6. From what position did a scout find that the Church in 2395 was 50°, and the Church in 2494 was 112° by the compass ?

7. Give the field sketching signs for :—

(*a*) A double line of railway through a cutting 30 ft. deep.

(*b*) Field telephone line (buried).

(*c*) Sign post.

(*d*) Church with tower.

(*e*) A windmill.

(*f*) A wood that has been cleared.

Test I.—On Plate L.

(Magnetic variation is 15° West of Grid North.)

1. On a journey by road from BURY to COMBE give, in order, the heights of the contours which cut the road on the map.

2. At what part of its course does the road named in No. 1 pass through (*a*) A salient; and (*b*) A re-entrant? (*c*) What is the steepest gradient on the road?

3. A man is posted at 380410. Can he see a person at :—(*a*) 370420; (*b*) 397410; and (*c*) The Church spire at BURY?

4. In what time can a cyclist complete the journey from 404426 to 366428 and back, averaging 9 miles per hour on the outward journey and 11 miles per hour on the return, with a wait of 15 mins. at COMBE?

5. From 400420 what are the compass bearings of the Churches at BURY and COMBE?

6. If an enlargement of part of the map be required at $\frac{1}{2\,5\,3\,4\,4}$, what proportion should there be between the squares on the map and those on the enlargement?

7. Make (from the scales on the Service Protractor) a scale of yards for the enlargement at $\frac{1}{2\,5\,3\,4\,4}$.

Test J.—On Plate L.

A party is marching along the road shown from 425430 to 396370.

1. If the average rate of marching is 3 miles per hour, and the head of the column passes the bridge in 4141 at 10 a.m., at what time is it due at 396370?

2. State where in the course of the march the road (*a*) Crosses a salient; (*b*) Traverses a re-entrant; and (*c*) Follows a fairly level course. (*d*) What is the height of the ring contour in 4142?

3. (*a*) From what point on the line of march will the party first see South Farm (3840) ?

(*b*) When at 413413 can a man see :—(i) BURY ; (ii) KEYNES ; (iii) Cross roads in 4339 ?

4. A scout found that the church tower in 4439 was at a compass bearing of 125° while that at 424425 was 12°. State his position on the map.

5. (*a*) An aeroplane was 50 ft. above 413398. Will it be visible to a person on the road at 413416 ?

(*b*) If the aeroplane landed at 410390 what was the gradient of its descent ?

6. When the party was on the bridge over the River Avon, how could the map have been set without a compass ?

7. Show by sketching signs on the map :—

(*a*) Marsh from 431408 to 440400.

(*b*) Pine woods in the eastern part of 4441.

(*c*) Pontoon bridge at 444403.

(*d*) The river at 444403 is 50 ft. wide and 10 ft. deep, and the banks are 4 ft. high.

(*e*) Passenger ferry at 430414.

Test K.—On Plate L.

1. Regimental transport has to travel by road from 366428 by way of BORNE to the cross roads in 4339.

(*a*) How long will it take for the journey at 9 miles per hour ?

(*b*) Make a time scale for the transport.

2. What is the gradient on the road between :—
(*a*) 388400 and 397389 ; (*b*) 397389 and 398386 ?

3. A scout has to proceed at night from the end of the old road 398397 to 406417; thence to 401422; and from there back to the road at 381405. What compass bearings would be noted, and what was the length of each part of the journey?

4. From an observation post at 367401, how much of the road is visible:—(*a*) Between 418424 and 450406; and (*b*) 434414 and 450423?

5. (*a*) What is the height of the ring contour around 407413?

(*b*) What does it represent?

(*c*) What land feature is about 405415?

Also (*d*) From 407413 to 425397.

And (*e*) From 403408 to 420390.

6. You have to enlarge part of this map to a scale of $\frac{1}{10800}$. Make a scale of yards for use with this enlargement.

7. Draw a kilometre square at $\frac{1}{72000}$ and at the west side of it show the Headquarters 17th Infantry Brigade, and near it the Headquarters, 2nd Bn. Hopshire Regiment, with "A," "B" and "C" Companies in position. At the eastern side of the square show "D" Company with two platoons occupying a position facing east, and one platoon in reserve at Company Headquarters. There is a section of two machine guns with "D" Company.

Test L.—On Plate L.

A battalion is marching from 443370 along the road to 401430.

1. If the rate of marching is $3\frac{1}{3}$ miles per hour, how long will the journey take?

2. An observer is at 433376.

(*a*) How much of the line of march can he see ?

(*b*) How much can he see of the road from 434394 to 396370 ?

3. (*a*) On the line of road, what steep gradients are there ?

(*b*) Which is the most level part of the road ?

(*c*) If 431400 is at a height of 120 ft., what is the gradient between that point and 433396 ?

4. When the Abbey (4242) was on a compass bearing of 29°, a person found that the Church in 4042 was 335°. What was his position ?

5. If the river at 407430 is at a level of 95 ft. and at 450404 is 85 ft., what is the average fall of the river in its course across the map ?

6. Show on the map a single line of railway from 404430, crossing the road by an iron bridge at 416422 and crossing the river by iron bridges where necessary, and leaving the map at 450395. Mark embankments where necessary, and show stations for Bury, Wick and Newton.

7. Show on the map :—

(*a*) At Newton—9th Field Hospital.

(*b*) At Heron House 4438—Headquarters, First Army and near by a Radio Telephone Station.

(*c*) At 440388—a Supply Dump.

(*d*) At Wick—6th Division Headquarters ; an Armoured Car Squadron ; 6th Divisional M.T. Column.

Test M.—On Plate L.

A force occupies the high land shown in 4137, 4237 and 4337.

1. To an observer at 420377 what is the appearance of the land to the west of a line from his position to Moor Farm ?

2. A machine-gun post at 420377 is taking the compass bearings of 403378, 408387, 412389, and 434394. What should be the readings ?

3. From 420377 an aeroplane vertically above the cross roads 442381 is observed to be at an angle of elevation of 3°. What is its approximate height above the ground ?

4. (*a*) How long would it take armoured cars at 20 miles per hour to travel along the road from 396370 to 450399 ?

(*b*) Make a time scale for the cars.

5. An observer found that when the Church in 4439 was on a compass bearing of 119°, the post at 420377 was 219°. What was his position ?

6. You have to enlarge part of this map to a scale of $\frac{1}{12672}$. Make (from the scales on your Service Protractor) a scale of yards for the enlargement.

7. Make two " kilometre squares " at $\frac{1}{14400}$, and in them show V Corps Headquarters ; a Signal Office ; Wireless Telegraph Station ; 10th Field Hospital ; Corps Supply Dump ; and 179th Anti-Aircraft Battery.

Test N.—On Plate A.

(Mag. Variation 11° W. of Grid North.)

The leading company of a battalion reaches the bridge 404741 at 9 a.m. on its march along the main road to Guildford.

1. At $2\frac{1}{2}$ miles per hour, at what time should it reach the bridge at 430702 ?

2. When it reaches the turn in the road at 410727, how could the map be set without the use of a compass ?

3. How does the gradient on the journey up the hill into Worplesdon compare with the road out of it to the south-east ?

4. From the tower of Worplesdon Church can an observer see (*a*) a tower 50 ft. high at 424711 and (*b*) a lorry on the road at point 134 in 4071 ?

5. What are the compass bearings from Worplesdon Church of (*a*) the road junction near Fairland's Farm and (*b*) the bridge over the railway in 4273 ?

6. (*a*) Give the map references of the three places mentioned in the last question.

(*b*) Explain what is meant by the letters (i) P in 4073 ; (ii) Pt. in 4074 ; (iii) t.c.b. in 4870.

7. Enlarge to a scale of $\frac{1}{21120}$ the squares 4272 and 4372.

Test O.—On Plate A.

A company is on the road in 4268, on its way westwards.

1. (*a*) How long would it take them at 2½ miles per hour to move along the road between the spot level 265 and Trig. Point 505 ?

(*b*) Make a marching scale for 2½ miles per hour.

2. (*a*) What is the average gradient on the road between the two points in question 1 (*a*) ?

(*b*) Is the slope between these spot levels concave or convex ?

3. From a point on the road near 413682, how much of the railway in squares 4069, 4169 and 4269 can be seen ?

4. A scout found that from his position the church in 3966 was at a compass bearing of 79°, while the church in 3764 was 10°. What was the scout's position ?

5. A patrol was to be sent from the road junction 393668, along the road to Compton, thence via Newpond to the road bridge over the railway in 4265.

Prepare at a scale of 2 ins. to a mile a road sketch of the district for use by such a party. Note particularly the type of road as shown by the colouring.

6. What are represented on the map at (*a*) ; Around 389674 ; (*b*) Around 416736 ; (*c*) 441687 ?

(*d*) What kind of ferry is shown across the River Wey south of Guildford ?

7. From the road at spot height 265 (424686) a kite can be seen over the road junction 425704. What is the least possible height of the kite above ground ?

Test P.—On Plate A.

A battalion, halted for the night, occupied the front along the road from 380644 to 390649.

1. From 38356480, a point in its forward zone, a patrol had to move by night to 376653, thence along the cart track until it meets the road at 373660, then to the Rd. Junction at 385666.

(*a*) What compass bearings should be noted for the journey ?

(*b*) What is the length in yards of each part of the journey ?

2. The vanguard moves off 6 a.m. from 382644 and marches by way of 389650 to the road junction at 385666.

(*a*) At $2\frac{1}{2}$ miles per hour, when should it reach 385666 ?

(*b*) What is the highest point on the line of march ?

(*c*) What is the steepest gradient on the road ?

3. (*a*) At what point on the road will the vanguard come into view of a party already at the S.W. corner of the wood at 382666 ?

(*b*) Can the party at 382666 see troops on the road at 377678 (Height 455 ft.) ?

4. (*a*) From 377678 how much of the road running N.W. from 385666 will be visible ?

(*b*) What are the heights of the ring contours in 3867 ?

5. Make a sketch of square 3865 on a scale of $\frac{1}{7200}$.

6. Prepare a scale of yards for the enlargement.

7. Describe the type of country and shape of the ground which the patrol in Question 1 will have to traverse.

ANSWERS

EXERCISE I

1.

(*a*) 5406.
(*b*) 6010.
(*c*) 5503.
(*d*) 5800.
(*e*) 6002.
(*f*) 4905.

2.

(*a*) 545068.
(*b*) 604103.
(*c*) 553036.
(*d*) 585008.
(*e*) 605027.
(*f*) 494054.

3.

(*a*) The Lodge.
(*b*) The Bridge near the Mill.
(*c*) Longton Church.
(*d*) N. corner of Lodge enclosure.
(*e*) Road junction near the Forge.
(*f*) Shooting Box.

4.

(*a*) 584098.
(*b*) 548072.
(*c*) 564003.
(*d*) 607057.
(*e*) 501101.
(*f*) 588993.

5.

(*a*) Cross Roads at Hood.
(*b*) Road junction near Brown's Farm.
(*c*) N. corner of Abbey enclosure.
(*d*) Nelson Church.
(*e*) Point where the railway cuts the S. edge of the map.
(*f*) E. corner of Abbey enclosure.

6.	E.	N.
(*a*)	454500 m.	106800 m.
(*b*)	460400 m.	110300 m.
(*c*)	455300 m.	103600 m.
(*d*)	458500 m.	100800 m.
(*e*)	460500 m.	102700 m.
(*f*)	499400 m.	105400 m.

7.

(*a*)	58440978.	(*d*)	60640578.
(*b*)	54700720.	(*e*)	50121015.
(*c*)	56450025.	(*f*)	58819933.

8.

(*a*)	603015.	(*d*)	622006.
(*b*)	614001.	(*e*)	621016.
(*c*)	604007.	(*f*)	615011.

9.

(*a*)	Ryton Church.	(*d*)	Cole's Farm.
(*b*)	Brook Cottage.	(*e*)	The Creamery.
(*c*)	Park House.	(*f*)	The Inn.

10.

(*a*)	62860142.	(*d*)	61840168.
(*b*)	60370033.	(*e*)	62500032.
(*c*)	60460177.	(*f*)	62350185.

11.

(*a*)	60300150.	(*d*)	62240061.
(*b*)	61450014,	(*e*)	62110162.
(*c*)	60430074.	(*f*)	61530110.

12	E.	N.
(*a*)	462860 m.	101420 m.
(*b*)	460370 m.	100330 m.
(*c*)	460460 m.	101770 m.
(*d*)	461840 m.	101680 m.
(*e*)	462500 m.	100320 m.
(*f*)	462350 m.	101850 m.

13. (*a*) Church with tower.
(*b*) Cutting along railway.
(*c*) Embankment along railway.

14. (*a*) Church without spire or tower.
(*b*) Wind pump.
(*c*) A copse (deciduous).

15. (*a*) Road bridge over railway.
(*b*) Church with spire.
(*c*) The letters P t denote that Bellfields has a Post Office without telegraph but with telephone.

16. (*a*) Heath.
(*b*) Telephone call box.
(*c*) Electricity Transmission lines.

17. (*a*) Footpath.
(*b*) Spot Height denoting that the height above sea-level is 140 ft.
(*c*) The letter P denotes that Albury has a Post Office with telegraph and telephone facilities.

EXERCISE II

1. (*a*) 1 in. to 1 mile. (*b*) 4 ins. to 1 mile. (*c*) 3 ins. to 1 mile. (*d*) 6 ins. to 1 mile. (*e*) 6·3 ins. to 1 mile. (*f*) 3·9 miles to 1 in. (*g*) 1 in. to 200 yds. (*h*) 8 ins. to 1 mile.

2. The denominators of the R.Fs. are :—31680 ; 190080 ; 42240 ; 126720 ; 36000 ; 4800.

3. Denominators :—(*a*) 28800 ; (*b*) 7200 ; (*c*) 18000 ; (*d*) 8000 ; (*e*) 17280 ; (*f*) 19200 ; (*g*) 39600 ; (*h*) 9900.

4. (*a*) 1672 ; 3256 ; 4180 ; 3608 ; 2376 ; 2860 yds. (*b*) $1114\frac{2}{3}$; $2170\frac{2}{3}$; $2786\frac{2}{3}$; $2405\frac{1}{3}$; 1584 ; $1906\frac{2}{3}$ yds. (*c*) 2675·2 ; 5209·6 ; 6688 ; 5772·8 ; 3801·6 ; 4576 yds. (*d*) $1910\frac{6}{7}$; $3721\frac{1}{7}$; $4777\frac{1}{7}$; $4123\frac{3}{7}$; $2715\frac{3}{7}$; $3268\frac{4}{7}$ yds.

5. (*a*) 1·13 ins. ; 3·34 ins. ; 2·04 ins ; 3·92 ins. (*b*) 3·4 ins. ; 10·02 ins. ; 6·13 ins. ; 11·76 ins. (*c*) ·18 ins. ·55 in. ; ·34 in. ; ·65 in. (*d*) 1·42 ins. ; 4·17 ins. ; 2·55 ins. ; 4·9 ins.

6. (*a*) $22\frac{1}{2}$ ins. ; 13·63 ins. ; 16·8 ins. ; 7·32 ins. ; $3\frac{3}{4}$ ins. (*b*) 22 ins. ; 13·3 ins. ; 16·4 ins. ; 7·16 ins. ; $3\frac{2}{3}$ ins. (*c*) 2·37 ins. ; 1·44 ins. ; 1·77 ins. ; ·77 in. ; ·39 in. (*d*) 15 ins. ; 9·1 ins. ; 11·2 ins. ; 4·88 ins. ; $2\frac{1}{2}$ ins.

7. (*a*) Cavalry, $2\frac{3}{4}$ mins. ; $4\frac{1}{2}$ mins. ; $\frac{7}{8}$ mins. ; $3\frac{4}{5}$ mins. (*b*) Artillery, 3·2 mins. ; 5·2 mins. ; 1·02 mins. ; 4·4 mins. (*c*) Infantry, $9\frac{1}{6}$ mins. ; 15 mins. ; $2\frac{1}{1\frac{1}{2}}$ mins. ; $12\frac{2}{3}$ mins.

8. (*a*) 45·3 mins. ; 25·2 mins. ; 67 mins. ; 85·2 mins. (*b*) 28·3 mins. ; 15·7 mins. ; 41·9 mins. ; 53·2 mins. (*c*) 17 mins. ; 9·4 mins. ; 25·1 mins. ; 31·9 mins.

9. (*a*) Line 5·6 ins. represents 2500 yds. (*b*) 5·96 ins. for 3500 yds. (*c*) 5·68 ins. for 5000 yds.

10. (*a*) $\frac{1}{10560}$; (*b*) $\frac{1}{12672}$.

11. Four ins. to the mile, $\frac{1}{15840}$.

12. Four miles to the inch, $\frac{1}{253440}$.

13. (*a*) ·36 in. × ·34 in.; ·63 in. × ·34 in.; ·9 in. × ·56 in. (*b*) ·54 × ·51 in.; ·95 in. × ·51 in.; 1·36 in. × ·85 in. (*c*) ·23 in. × ·21 in.; ·4 in. × ·21 in.; ·57 in. × ·36 in. (*d*) ·22 in. × ·21 in.; ·39 in. × ·21 in.; ·56 in. × ·35 in.

14. R.F. $= \frac{5}{1000} \times \frac{1}{100} = \frac{1}{20000}$.

15. Scale 2 ins. to 1 mile.

(*a*) *Infantry.* 6 ins. = 60 mins.
Divide a 6-in. line into six divisions representing 10 minutes each, and sub-divide the left-hand division into 10 parts, showing minutes.

(*b*) *Cavalry.* 8 ins. = 60 mins.
Take a line $6\frac{2}{3}$ ins. = 50 mins., and divide it as above.

16. 13·87 miles.

EXERCISE III

1. 34 mins.

2. 1 hr. 12 mins.

3. 6,700 yds.; 4,920 yds.; 10,500 yds.

4. 2 mins.

5. 11 mins.

6. 9.47 a.m.

7. At the scale of the map, $5\frac{1}{2}$ ins. would represent 110 mins.—*i.e.*, each $\frac{1}{2}$ in. would represent a 10-minute division; the left-hand division should be subdivided into secondary parts.

8. 4 hrs. 27 mins.
9. 15 mins.
10. 3,200 yds.
11. 1,020 yds.; 1,210 yds.; 1,900 yds.
12. 22 mins.
13. 740 yds.; 1,870 yds.; 2,240 yds.
14. 1·056 ins. would represent 10 mins.
15. 1 mile; 1,900 yds.
16. 1,340 yds.; 1,015 yds.; 860 yds.
17. 1·01 secs.
18. 1 mile 950 yds.
19. 1,350 yds.
20. 540 yds.
21. 25 mins.
22. 4 hrs. 24 mins.
23. 28½ mins.
24. 10·28 a.m.
25. 1 hr. 5 mins.

EXERCISE IV

1. 250, 300, 350, 400, 400, 350, 300 ft.
2. 350 ft.
3. 440 ft.; 600 ft.
4. 105 ft.
5. Concave; concave.
6. By way of road junction in 5007, Barham, and road junction in 5904.
7. About as far as 570096 and 595096.
8. Convex; convex.

9. 150 ft.
10. (*a*) 300 and 400 ft.; (*b*) 250 ft.
11. Convex.
12. Concave.
13. Convex.
14. Concave; convex.
15. 416 ft.
16. 120 ft.

EXERCISE V

1. 1 in 60.
2. 1 in 168.
3. 1 in 255.
4. 1 in 33.

That part of the road near Hood where the road for about a mile is almost at a level of 350 ft.

5. 2°.
6. 1 in 102.
7. 1 in 106.
8. 460 ft.
9. 1 in 350.
10. 1 in 43.
11. 1 in 50; 1°.
12. 1 in 170.
13. 1 in 300.
14. 1 in 69.
15. 1 in 150.
16. 1 in 72.
17. 1 in 40.
18. 1 in 70.

EXERCISE VII

1. Yes ; No.
2. About 145 ft.
3. No. ; yes.
4. About 568034.
5. From 510034 to 537002.
6. Yes ; yes ; no.
7. All.
8. 160 ft.
9. Yes ; no.
10. No ; yes.
11. Yes.
12. Yes, both.
13. About 418705.
14. (*a*) Yes. (*b*) The copse on the direct line between the points.
15. 441731 ; 441731.
16. About 433727.

EXERCISE VIII

1. Grid 37°, 325° 30′. Magnetic 50°, 338° 30′.
2. 278°, 173°.
3. 104° ; 335°.
4. Grid 27°, 225°, 262°. Magnetic 40°, 238°, 275°.
5. 58° ; 299°.
6. 40°.
7. 231° ; 160° ; 89°.
8. 310° ; 21°.
9. 2° W.

10. 56°; 297°.

11. 240°; 81°; 152°.

12. 198°; 61°; 2°.

13. Grid 308°; 34°. Magnetic 319°, 45°.

14. 322°; 235°;

15. 1°; 212°.

16. 127°; 333°.

17. 63°; 332°.

18. 124°; 100°.

19. 319°; 298°: 249°.

20. 178°; 193°; 244°.

EXERCISE IX

1. Pt. 360.

2. Pt. 365.

3. There are three lines of road by which to set; the line of railway gives a useful check.

4. 574033.

5. 550025.

6. Pt. 365.

7. Road junction in 5201.

8. 494045.

9. 590085.

10. 510070.

11. In this case the straight line of railway is excellent for setting the map. Worplesdon Church forms an excellent point for checking.

12. 406718.

13. Here there are several lines for setting—railway, road, and river. Check points would be the Motor Vehicle Works (424700), and the Church at 434692.

14. 440730.

15. 466686.

16. 428730.

17. 395708.

18. The lines of the river crossed by the road form the best guide for setting. Check points are provided by Burpham Church (452718) and several belts of woodland.

19. 433746.

20. 430660.

EXERCISE X.

1. 587 yds. (1·66 ins.).

2. The side of each square would be 3·73 ins. long.

3. Side of squares three times that of the original—R.F. $\frac{1}{21120}$.

4. Side of squares four times that of the original.

5. R.F. $\frac{1}{10560}$.

6. R.F. $\frac{1}{14400}$. Prepare a scale of yards and draw the squares with sides of 1,094 yds. (2·75 ins.).

7. 2 ins. to 1 mile. A map such as this is really a skeleton map.

8. R.F. $\frac{1}{7200}$. Sides of squares 1094 yds.

9. 300 yds. to 1 inch.

10. Copy the triangle formed by joining the three points at a scale of 200 yds. to 1 inch.

ANSWERS

MAP READING TESTS

A.

1. About 12·31.

2. 1 in 30. In square 4905.

3. No.

4. See Chapter X for setting the map. In this case the three roads afford excellent lines for setting the map, while Barham Church affords one good point for checking.

5. 510601.

6. About 520 ft.

B.

1. 1 hr. 10 mins.

2. (*a*) 553035.

(*b*) Yes, except west of the road junction in 5004, where the road is visible from the high land about Pt. 365 in 5109.

3. Shooting Box, 0°; 7,250 yds. Nelson Cross Roads, 33°; 7,850 yds. Deep Cross Roads, 73°; 5,700 yds.

4. 1 in 46.

5. (*a*) 350 ft.

(*b*) (i) The ring contour in (*a*) is a knoll. (ii) 567036, a col occurs between the ring contour and the main feature of the hill. (iii) From 570025 to 573007. (iv) From 566060 to 585045.

6. About 1 in 35.

C.

1. (*a*) Concave. (*b*) A ridge. (*c*) A col.

2. The whole of the road in front is visible, except between 544093 and 562093, and that part of the road east of 603095. The cross roads at Nelson would probably just be visible.

3. Pt. 420 ; 581081.

4. The side of the enlarged square should be three times the side of the original square. Such an enlargement should state clearly :—

(*a*) The name of the map and the square.

(*b*) The scale of the enlargement.

(*c*) A scale line showing yards ; in this case, the necessary lengths can be adapted from the scales of yards shown on the Service Protractor.

5. 1 hr. 32 mins.

6. A line 5 ins. long represents 30 mins. This should be suitably subdivided in 5 or 10 minute divisions.

D.

1. About 10 mins. (9·6).

2. A line $6\frac{1}{4}$ ins. long will represent 15 mins. Subdivide into 5-minute divisions and the secondary division into minutes.

3. It is possible that it will be visible about 182907 and then be lost to view until it reappears when it reaches 186939.

4. (*a*) 1 in 40. (*b*) Fairly uniform.

5. 5° East. The amount of the compass error could simply be calculated by a comparison of the actual reading on the ground, with that shown on a survey map. In general, a compass can be checked by taking a bearing between two clearly charted points on a fair scale map, say $\frac{1}{25000}$; the map and compass readings, in both directions, will form a valuable check. In this case the grid bearing measured on the map is 332°, therefore the correct magnetic bearing is 345°.

6. The lines of road give excellent lines for setting. There are several prominent land features and two churches as checking points.

7. (i) Col around 180935. (ii) Salient from 187930 to 185935. (iii) Re-entrant from 183923 to 177919. (iv) There are several well-marked watercourses shown occupied by streams.

E.

1. (*a*) About 19 mins. (*b*) 1 in 54, between 218932 and 217939.

2. (*a*) 350 ft.; this contour represents a knoll. (*b*) Yes, there is good shelter behind the knoll.

3. 224912 would be much the better position. It is 50 ft. higher than 220910 and the view towards 215939 is unrestricted.

4. 217937.

6. 1 in 15.

F.

1. About 17 mins.

2. A line 6 ins. long represents 30 mins.; divide into 5-minute divisions, and the secondary division into minutes.

3. (*a*) Yes. (*b*) No. (*c*) 242914.

4. 1 in 31; 2° of slope.

5. 250930.

6. (*a*) 400 ft. (*b*) A knoll. (*c*) Salient. (*d*) A col.

G.

1. (*a*) About 234924. (*b*) Seen from 259910. (*c*) Convex. (*d*) Concave.

2. 21 mins.

3. 269°; 70°; 139°.

4. About 110 ft. above the ground.

5. (*a*) T indicates that a town has a telegraph office. P—that it has a post office with telegraph and telephone facilities. P t—that it has a post office with telephone facilities.

(*b*) 19109153; 23459560.

6. Yes, they would help to give an idea of what the higher land looked like.

H.

1. (*a*) 4,600 yds.
   (*b*) Yes.
   (*c*) Yes.
2. (*a*) 97°; 100°.
   (*b*) 2,000 yds.; 2,500 yds.
   (*c*) 28 mins.; 34 mins.
3. 1 in 184.
4. (*a*) 400 ft. (*b*) Col. (*c*) Salient. (*d*) Re-entrant.
5. (*a*) For a V.I. of 50 ft. 1° of slope gives a H.E. of $19{\cdot}1 \times 50 = 955$ yds.

At the scale of the map this will be represented by ·95 ins.; 2° will be half of this; 3° will be one-third of it.

(*b*) Less than 1° of slope are the roads from 246923 to 260927 and from 244920 to 260919 (this is fairly level). Steeper than 3° are the roads from 225923 to 231924 and from 243921 to 246923.

6. 230950.

I.

1. 100, 150, 200, 250, 250, 200, 200, 250, 250, 200, 200, 200 ft.

2. (*a*) Across salient from 376414 to 373418. (*b*) Re-entrants from 388417 to 400420 ; from 377412 to 376414 ; and from 373418 to 371422.

(*c*) 1 in 18 at about 377411.

3. (*a*) No. (*b*) No. (*c*) Yes.

4. 58 mins.

5. 36° ; 292°.

6. Scale 2½ ins. to 1 mile. The squares on the enlargement should be 2½ times those on the original.

7. A line 4,000 yds. should be taken and suitably divided. Test the length of this line ; it should be 5·7 ins.

J.

1. 11.9 a.m.

2. (*a*) Salient from 413410 to 414399.

(*b*) Re-entrant 423429 to 419424.

(*c*) The most level part is about 408386 to 396370.

(*d*) 200 ft.

3. (*a*) 414404.

(*b*) (i) Probably only the church can be seen. (ii) Yes. (iii) No.

4. 424404.

5. (*a*) No. (*b*) 1 in 60.

6. The intersection of road and river give excellent lines for setting the map. The churches at Keynes and Bury afford good checking points.

K.

1. (*a*) 40 mins.

(*b*) A 6 in. line represents 40 mins.' travelling.

2. 1 in 100 ; 1 in 20.

3. (i) 38° ; 2,400 yds. (ii) 335° ; 850 yds. (iii) 245 ; 3,000 yds.

4. From 438411 to 450406 would probably be visible, as would also 436416 to 450423. (It should be remembered that in distances such as those involved in this question, glasses would be needed, and much depends on visibility conditions.)

5. (*a*) 250 ft. (*b*) Knoll. (*c*) Col. (*d*) Salient. (*e*) Re-entrant.

6. 300 yds. to 1 inch. Primaries of 1 inch representing 300 yds., and secondaries of $\frac{1}{6}$ of an inch representing 50 yds.

7. Scale 200 yds. to 1 inch. Construct a scale line and draw a square of side 1,094 yds.

L.

1. 1 hr. 28 mins.

2. (*a*) From about 441384 to 432399.

(*b*) 434394 to 417389.

3. (*a*) None.

(*b*) From 427406 to 419411, and from 413415 to 407420.

(*c*) 1 in 75.

4. 420410.

5. About 1 in 2250.

M.

1. From Moor Farm the higher land in the background rises gradually to the west by a long ridge over 250 ft. high, until beyond South Farm there is a steeper rise to over 400 ft.

From this high land the ground slopes rather uniformly southwards, and between these slopes and the salient at Moor Farm, there is a well-marked re-entrant to the north.

2. 289°; 326°; 341°; 54°.

3. The distance between the points is 7,500 ft. Now 3° of slope is 1 in 20.

∴ The rise is $\frac{1}{20}$ of 7,500 ft.—*i.e.*, 375 ft. P t 420377 is 200 ft. high. The plane is therefore 375+200 ft. above sea-level. But the cross roads have an altitude of 100 ft.

∴ The plane is about 475 ft. above the ground.

4. (*a*) 11 mins.

(*b*) A 5 in. line representing 5 miles will give 15 mins. on the scale line. This can be suitably divided.

5. 431300.

6. Scale 5 ins. to 1 mile. Take from the protractor a length of line to represent 2,000 yds. This should measure 5·68 ins.

N.

1. About 10.17 a.m.

2. The several lines of road afford an excellent guide for setting the map.

3. The gradient on the road up into Worplesdon is comparatively gentle; but that on the road to the south-east is very steep—at one point it is almost 1 in 7.

4. (*a*) Yes. (*b*) No.

5. 239°; 81°.

6. (*a*) 412730; 403722; 428736.

(*b*) (i) P denotes that Worplesdon has a post office with telegraph and telephone facilities.

(ii) P t denotes that here there is a post office with telephone but not telegraph facilities.

(iii) t.c.b. denotes that here there is a telephone call box.

O.

1. (*a*) 57 mins.

(*b*) This scale can be adapted from the scale of yards on the protractor. A line representing 4,000 yds. should, when tested, be 5·68 ins. long.

2. (*a*) 1 in 52½.

(*b*) Convex.

3. From 412696 eastwards the railway cutting can probably be seen. The railway line itself can probably be seen eastwards from 418697.

4. 379659.

5. A scale of yards at 2 ins. to the mile can be constructed from the Service Protractor.

6. (*a*) Denotes Parkland. (*b*) Heath. (*c*) Wind pump. (*d*) A ferry (F) for foot passengers only, and not vehicles.

7. 97 ft.

P.

1. (*a*) 312°; 72°.
(*b*) 800 yds.; 850 yds.; 950 yds.

2. (*a*) 6.42 a.m.
(*b*) 371 ft.
(*c*) About 1 in 11. The road at 390649 is about 260 ft. (very close to the 250 contour).

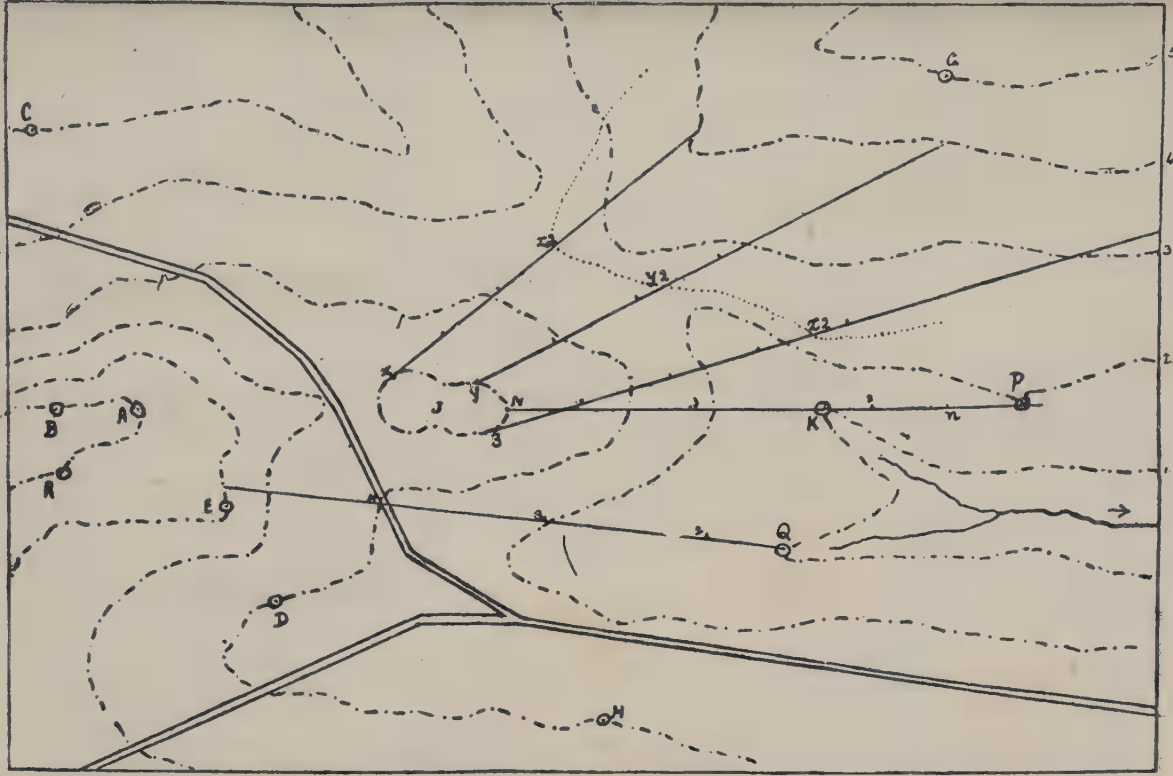
3. (*a*) 385665. (*b*) Yes.

4. (*a*) Between about 382667 and 379669; then from 376670 to 373683. (*b*) 350 ft.

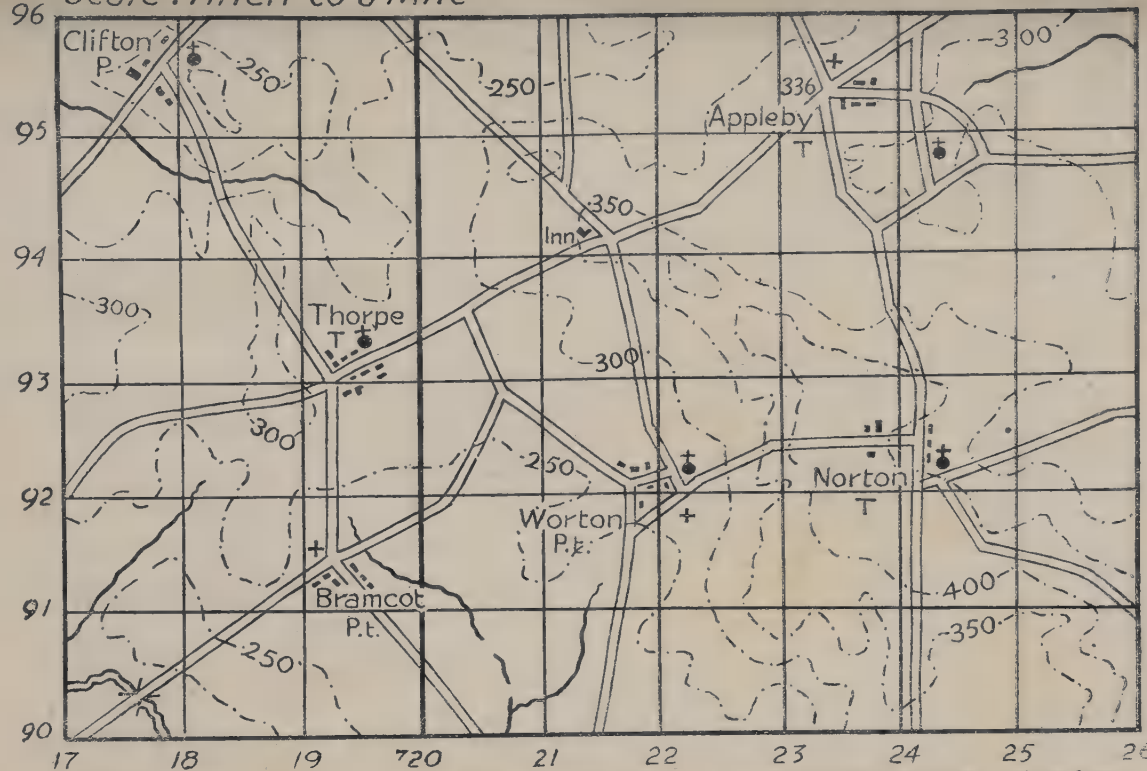
5. Scale—200 yds. to 1 inch.

6. Scale line 5 in. long. Primaries 1 inch. Secondaries $\frac{1}{10}$ inch representing 20 yds.

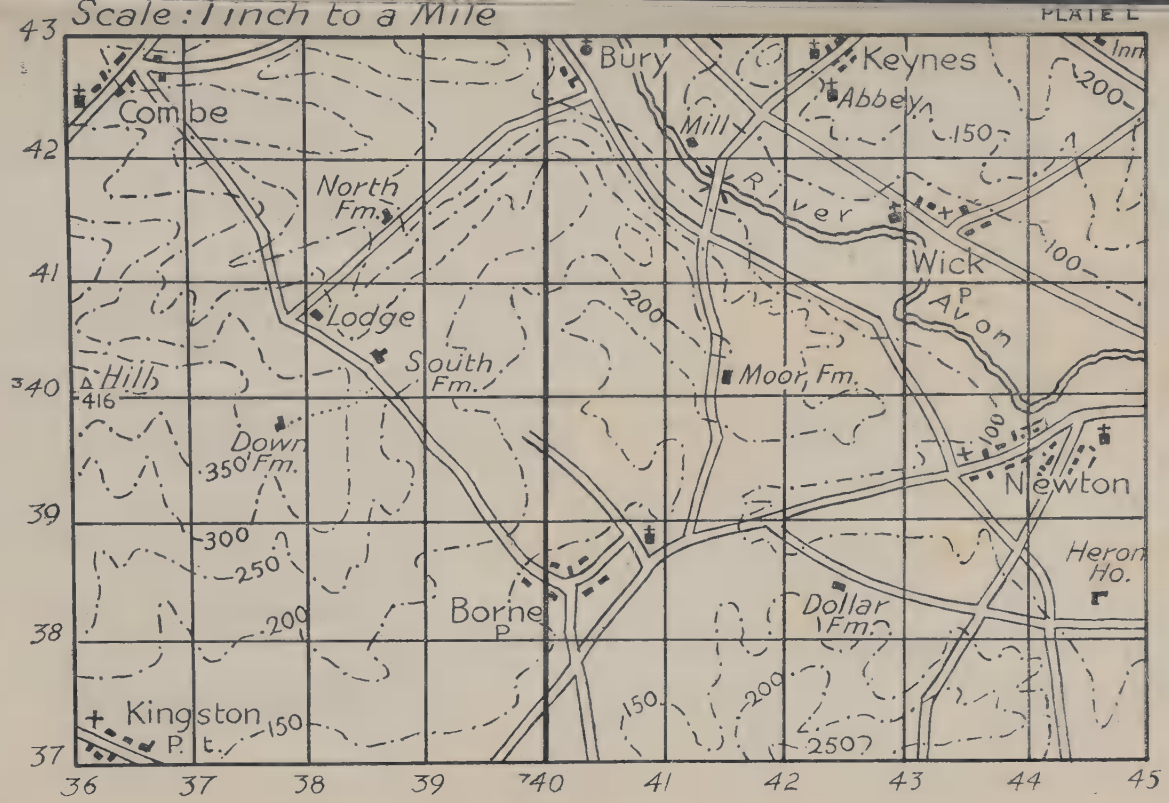
7. As far as can be ascertained from the map, the ground throughout the route is open except for a wooded area in the vicinity of the knoll at 351664. Along the first leg it falls gradually into a re-entrant, then the cart track rises along a slight salient. The last leg is over undulating ground which falls gradually from the knoll to the finishing point.



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